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the Petroleum Engineer

FOR MANAGEMENT

MARCH 1959

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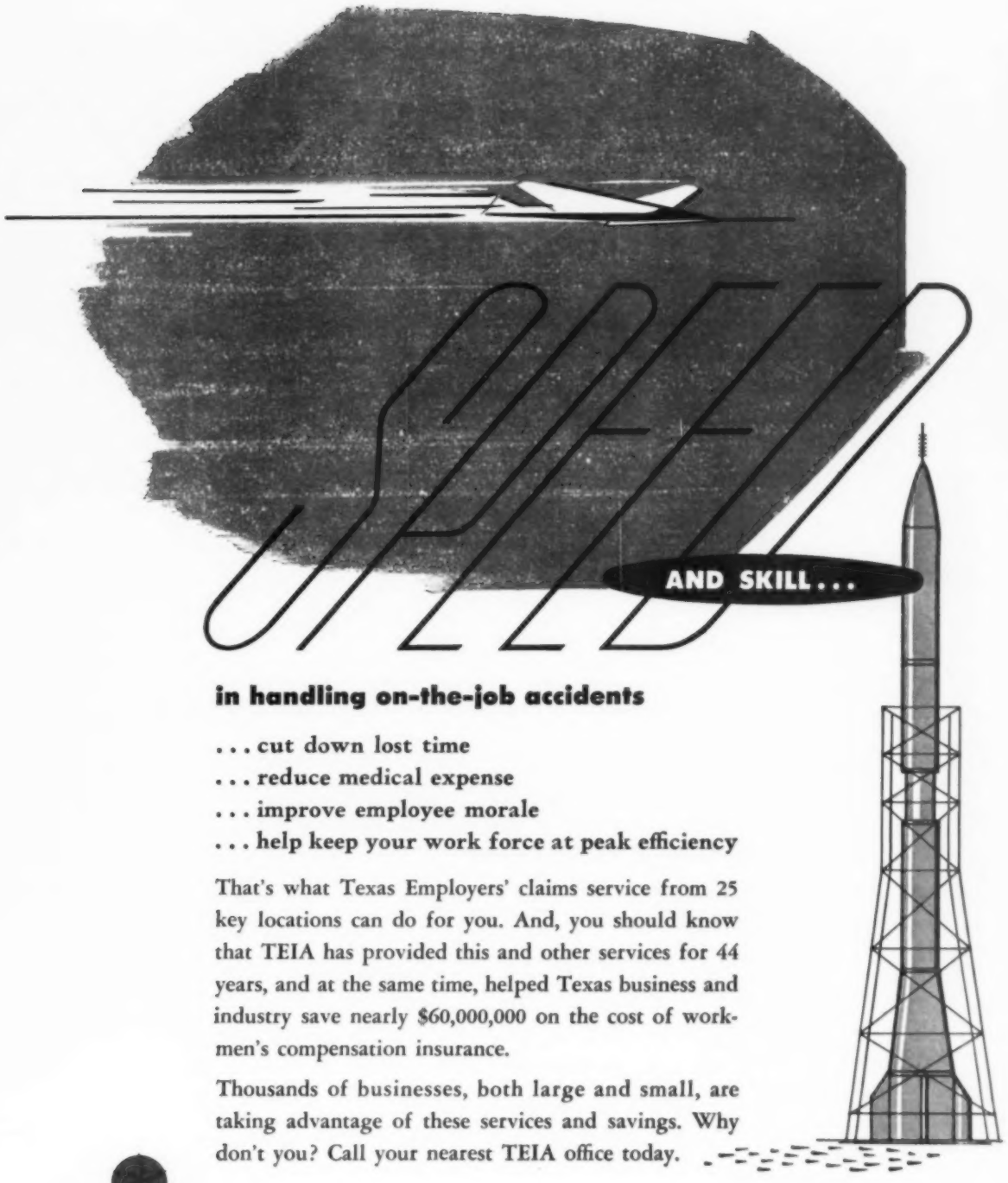

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THE PETROLEUM Engineer

FOR OPERATING MANAGEMENT / an integrated edition of The Petroleum Engineer

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THE PETROLEUM Engineer
FOR MANAGEMENT
INTEGRATED EDITION OF THE PETROLEUM ENGINEER

THE PETROLEUM Engineer
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The Essential Ingredient

DO YOU REMEMBER when engineers were in such tight supply that companies were bidding against each other for their services and the big personnel problem was turnover? At that time we published a survey on why engineers change jobs. You may have been as startled as we were at the results. The chief reason for changing jobs was not "money" — it was ninth on the list — or opportunity — it was implied rather than stated. Major cause for job changing was ineffective management — lack of confidence in administration, low morale of associates, a feeling that talents were not used by the organization they left.

This was a pretty sharp indictment and added to the already growing realization that management played the leading role in business and industry.

Our great economics reformer, Adam Smith, said the key to a nation's wealth is "the skill, dexterity and judgment with which its labor is generally applied." It took us a long time to see that management directs the application.

Until recently management was little examined or given much credit. Perhaps because our economy grew up in an owner-manager situation where power was transferred to heirs and excellence was more hoped for than instilled. Labor unions sprang up as the result of bad management and the skills of labor were extolled too loudly to hear the melody of good management.

What is good management? If you are a reader of *The Petroleum Engineer* you are probably a manager of one or more persons. Can you tell us what makes a good superior executive?

You can see how intangible are the qualifications — how hard to pinpoint with words. That's not surprising as we've only in the last generation even made an attempt. All of a sudden we lifted our eyes from the industrial revolution and grasped a long-concealed truth — people are the core of economics. And with this came the recognition — still growing — that our industrial progress had developed more skill in using materials and equipment and methods than in handling men. Then we glimpsed a new idea — that management was probably more psychology than technology — and more philosophy than either.

THERE IS NO PRECISE study or formula for executive preparation. No one can say — do this and that and you will be a good manager. All we can say is — this is what successful executives do and these are the qualities, the education, the attitudes they have found useful. In a budding profession, that is the help we offer in our series, "How to be a Manager."

These facts we do know! No company, no industry, no country can long endure without good executives to direct them. Business leadership is not born; it must be developed. Development cannot be spread on like jam; it must be taken internally.

In our high economic level, dedication to excellence is not always necessary to a satisfactory life, but good management is the essential ingredient to nurture our progress.

To be a good manager is commitment without end. Your largest reward is the satisfaction of achievement. We need you. Are you a recruit?

Ernestine Adams

Congrats and $25 for this quip to Mrs. Merlyn Goodman, Rt. 5, Box 742, Shreveport, La.

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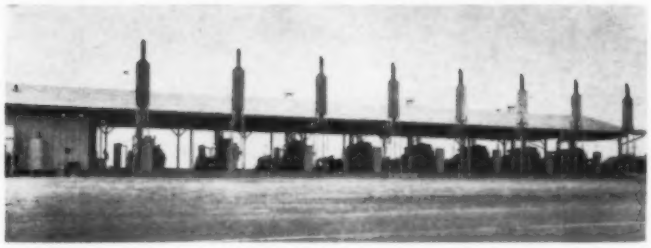
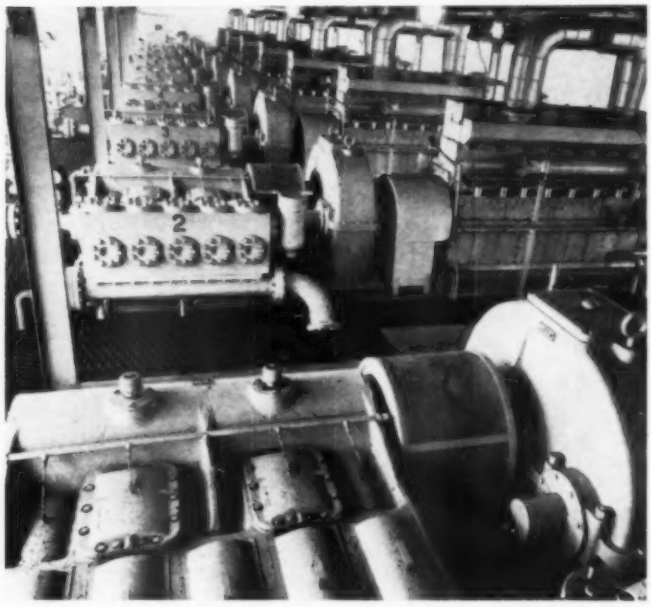


They're actually pumping the ocean . . .



Horizontal design assures quiet operation with minimum vibration and makes working parts readily accessible for servicing.

with "Oilwell" 558-P Quintuplex Plunger Pumps

THE WORLD'S MOST INTERESTING WATERFLOOD PROJECT is under way. The first batteries of "Oilwell" Pumps are injecting sea water into the oil sands of the Wilmington field in the Long Beach Harbor area.

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The conservative operating speed of these pumps will keep maintenance at a minimum. Any attention required will be simplified by their compact horizontal design, making working parts readily accessible.

Oil Well Supply makes a variety of superbly engineered pumps to fit all types of waterflood projects. Their "long service—low maintenance" records are worth investigating. "Oilwell" representatives will gladly talk with you about pumps for your next waterflood project.

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◀ Liquid ends are externally and internally machined from solid billets of aluminum bronze for maximum strength and resistance to sea water.

Petroleum Profile

IF YOU WERE DOING a graph of the career of Earl W. Unruh, president of Sinclair Pipe Line Company, you'd increase the upturn about 1941 and keep the curve on a steadily rising incline from then on.

For 1941 was the year the late W. W. Baker, vice president, gasoline division, Sinclair Prairie Oil Company, selected a group of young executives to bring to the Eastern headquarters of the company for training. One of these was young Earl Unruh, who was working in Sinclair's gasoline department in Tulsa.

"This was the most significant move in my career," he says today. He got acquainted with top management — an advantage to him because these people liked what they saw.

Earl Unruh, young and vigorous, has a solid Kansas background on which his flair for leadership is soundly based. He is the son of a Mennonite preacher, born in Newton, Kansas, and later attended school in Halstead. He received a degree in chemistry from Bethel College, North Newton, a small respected school, supported by his church. From there he entered Tulsa (Oklahoma) University where he worked as a laboratory assistant. Sequoyah Brown, then with Carter Oil, now vice president of Interstate Oil Pipe Line Company, hired him during one summer as an engineering trainee before he had his engineering degree. One semester at Tulsa University he taught some classes when a professor was on leave of absence, besides assisting in the laboratory. After the teacher returned, Earl looked about for some job in addition to being a laboratory instructor and was taken on part time by what was then Sinclair Prairie Oil Company. He worked in the gas and gas measurement department at odd hours whenever he could get away from his classes and job at the university.

When he earned his second degree — this time in chemical engineering, he became a full time employee in the gasoline department of Sinclair. About this time, too, he married his college sweetheart, Martha Penner from Minnesota.

During his sojourn in the East, Unruh helped plan and design Sinclair's first products line — from Philadelphia to the Baltimore and Pittsburgh areas. After its completion he was named chief dispatcher. Later he became chief engineer of products lines, in 1943, with offices in Columbus, Ohio.

The pipeline department of Sinclair was expanding. Crude oil and products lines were reaching into the corners of the United States. Earl Unruh was part of it — he'd helped build one of the largest systems in the country. He was part of the organization changes that made Sinclair Pipe Line Company in 1951 a separate entity, wholly owned by Sinclair Oil Corporation. At the time he was chief engineer of all lines — crude and products.

Before stepping from engineering to administrative work, Unruh in 1953 attended the advanced management course at Harvard University. This put further polish on his natural talent for creative business administration. He had barely assimilated this skill when he had need of it to handle the post of part-interest executive. His job was to look after Sinclair's interests in the company's ventures with other firms and in joint holdings in such lines as Arapahoe, Pioneer, Platte and others.

For his achievements in this position he was made operations vice president in January 1956, and in February 1957, he became president of Sinclair Pipe Line Company.

Only a trip to Independence, Kansas, can give the idea of the network operation of the company, which is represented by two large control boards. In 1957 crude oil traffic for Sinclair and associated companies totaled 474,000 barrels per day. Refined products amounted to 162,000 barrels per day. Sinclair has been a leader in advances in pipelining. It has extended facilities for automatic or remote control operations into nearly all its system.

EARL W. UNRUH
President
Sinclair Pipe Line Company

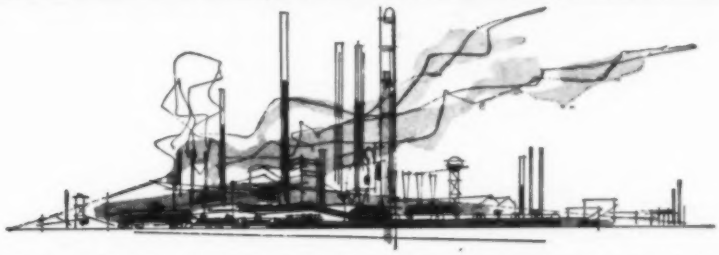
Heading this company is a challenging job and the new president took to it like a veteran.

As a person, Earl Unruh is a fine example of modern managers. He has turned a penetrating, engineer-trained mind to the problems of organization and human relations. The confidence and enthusiasm among the pipeliners of Independence and their accomplishments are visible results of the success of his efforts.

The Unruhs have three children. Bethel Ann is finishing high school and plans to go to her parents' alma mater next year. Rachael Ruth, 14, and Steven Theodore, 10, still have some grades to conquer in Independence.

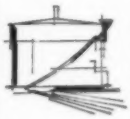
President Unruh, like most industry leaders, contributes time and effort to industry needs. A good speaker, he has lectured at the Corrosion Short Course. He is on the general committee of API Division of Transportation. He belongs to the Pipe Liners Club of Tulsa.

Perhaps his best contribution, however, will be his skillful use of more professional, more modern management methods.



General American does a lot more than just build tank cars

General American's design, engineering, fabrication and erection facilities are available to solve many processing and storage problems. Here are some of the products and services offered.



Conservation Structures

Tanks of all types for every kind of liquid. Cone roof structures and eight WIGGINS CONSERVATION SYSTEMS including floating roof types with the famous WIGGINS safety seal that reduces fire hazard and eliminates losses from thermal breathing.

Kanigen® Chemical Plating

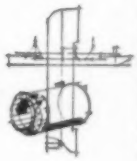
When your equipment must resist corrosion and abrasion, investigate KANIGEN® nickel alloy coating. From process equipment to tank car interiors, KANIGEN does the job economically and efficiently.

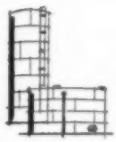
Gasholders

WIGGINS gasholders with patented dry fabric seal. No operating costs, no maintenance problems with the safest of all gas storage structures. Store practically every type of gas in commercial use safely and economically.

Custom Fabrication

All types of vessels, structures and weldments manufactured in our plants to meet all code specifications. Our engineers are on call to help you.



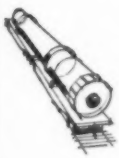


Water Storage

Standpipes, reservoirs and tanks are fabricated in our plants and erected by our specially trained crews

Field Erection

The Field Erection Division maintains experienced crews and modern, efficient erection equipment throughout the country.



Process Equipment

Louisville Dryers, Turbo-Mixers and process equipment of many types including RDC columns for extraction and reaction processes. Our experienced engineers will work with you on design problems. You can test processing ideas in our laboratories. You can rent pilot-scale dryers, mixers and columns for tests in your plant.

Strategic Locations

There is a General American plant in your area. Plants are located at Sharon, Pa.; East Chicago, Ind.; Birmingham, Ala.; Orem, Utah and Compton, Cal. Call us. You'll find ***it pays to plan with General American.***

Process Equipment Division *Plate and Welding*

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South LaSalle Street • Chicago 90, Illinois

THE CONFERENCE TABLE

A fellow who is always declaring he's no fool, usually has his doubts. —WILSON MIZNER

Management for Government

An advisory committee has been set up for management training of government career executives by American Management Association.

The new committee will review the needs for executive training in government jurisdictions, assess the training resources of the association, and discuss courses and other services AMA might supply to develop capable career administrators for the public service.

In our first chapter on "How to be a Manager" (Page A-22) we use the quotation from the Hoover Commission: "The greatest weakness in the Federal Government's personnel is inexpert managerial direction."

In private industry inefficient management takes a company off the scene. There is no such built-in protection for government management. Any improvement in developing more expert executives will help every working, tax-paying citizen.

★ *Worry is like a rocking chair. It will give you something to do but it won't get you anywhere.*

Fringes Equal 1/5 Wages

Employer payments for fringe benefits in 1957 averaged 21.8 percent of payroll, or $981 per full-time employee, according to a new survey made by the Chamber of Commerce of the United States Economic Research Department.

★ *All that I am or ever will be, I owe.*

Annual Reports Start Coming

The 1958 financial reports are no higher than has been expected. Most heartening thing is that the last quarter of most companies compared better with the last quarter of 1957 than any other quarter during 1958.

Ohio Oil Company had a preliminary net of $32,155,558 for the year compared to $41,490,280 for 1957. This is a drop of 22½ percent on the net for the year.

TXL Oil Corporation reported a net income of $3,745,979 for the fiscal year ending November 30, 1958. This compares with $4,346,152 net earnings for the previous year, or a 14 percent drop.

Atlantic Refining Company reported a net income of $33,825,000 in 1958 which was only 5 percent less than the $35,670,000 the previous year. The last half showed a strong upturn because the first six months of 1958 were nearly 70 percent below the first half of 1957.

Continental Oil Company's net earnings of $47,500,000 indicated a 2 percent increase over the 1957 net earnings of $46,700,000.

Sun Oil Company had a net income of $32,061,000 in 1958, which was 32 percent below the net income of $47,492,000 in 1957.

Tidewater Oil Company's net earnings in 1958 are estimated at $2,600,000 compared with $34,937,000 in 1957 it was announced by President George F. Getty II. After payment of dividends on the preferred stock of $2,995,000 the deficit applicable to common stock for the full year 1958 is estimated at $0.03 per share.

Standard Oil Company of California has a preliminary estimate of earnings of $258,000,000 for 1958. This compares with $288,230,000 in 1957, a decrease of 11 percent. The company's capital and exploratory expenditures for 1959 are budgeted at $400 million, an increase of some $50 million over the amounts expended in 1958. Of this total more than $250 million will be spent in developing oil fields.

Standard Oil (Indiana) estimated net 1958 earnings at $117,800,000. Net profits in 1957 were $151,509,000. Total income was estimated at $1,885,000,000 in 1958, as compared with $2,029,689,000 in 1957.

Husky Oil Company reports net earnings of $390,842 for the six months ended December 31, 1958, compared to $1,414,534 for the same period a year ago.

Bishop Oil Company's net income was $169,130, or 30 cents per share, for the year ended December 31, 1958. Net income in 1957 was $266,515, or 47 cents per share. 1958 gross income was $2,283,279, a decrease of $260,443 from the preceding year.

Kerr-McGee net earnings for the six months ended December 31, 1958, were $2,109,362, as compared with $2,536,228 for the first half of the preceding fiscal year. The second quarter earnings of $1,535,376 are substantially above the earnings of $573,986 reported for the first quarter.

Phillips Petroleum Company's net income for 1958 is estimated at $84,200,000, 12 percent less than the record of $96,200,000 in 1957. Capital expenditures were held to a minimum and totaled about $133,000,000, which was

$83,000,000 less than in 1957. It is anticipated that capital expenditures for 1959 will be about $135,000,000, which will require no financing.

Preliminary net income of Standard Oil Ohio for 1958 was $24,044,463, including non-recurring profit of $3,081,044. Final figures for 1957 were $23,920,335 net income, including non-recurring profit of $1,685,000.

Humble Oil & Refining Company's 1958 earnings indicate that the company's net income fell in 1958 to about $136,500,000. This is $39,410,400 less than 1957 when net income totaled $175,910,400.

Maracaibo Oil Exploration had a 1958 net income of $337,446 compared to $938,458 in 1957, which included $408,106 net capital gain on stock sales.

Socony Mobil Oil Company has reported a 29 percent decline in net profits for 1958. Earnings were estimated at $155,700,000, against $222,400,000 in 1957.

Woodley Petroleum Company had consolidated net income for 1958 of $3,094,451. This represents a decline of 6 percent from net income of $3,289,933 in 1957.

Engineer Enrollment Down

For the first time in seven years, and despite still critical demands for engineering talent, enrollment in American engineering schools is on the decline.

The 153 accredited American engineering colleges had 2.9 percent less students in the fall of 1958 than in the fall of 1957. And the freshman class which entered last fall was 11.6 percent smaller — 59,164 instead of 67,071 — than 1957.

Declining enrollments have not yet affected the number of engineering graduates — 31,216 in 1957-58 compared with 27,748 the previous year. But the numbers are far short of the record graduation of eight years ago, when World War II veterans were finishing their delayed college careers.

Enrollment figures come from the annual official survey students and degrees conducted by the American Society for Engineering Education in cooperation with the U. S. Office of Education.

★ *There are more than 12,000 businesses producing oil in this country, and the largest of these doesn't produce as much as six percent of total U. S. output.*

Wants Dollars Yet

YPF, the Argentina oil monopoly, has a contract with the Soviet Union for some 7 to 8 million bbl of oil to be delivered between July 1, 1958 and July 31, 1959. The interesting part of this contract is not so much that YPF is buying oil from Russia or how much, but the significant paragraphs in the contract that call for payment of all shipments in dollars. The price is at the rate of $2.33 per bbl for 31 to 31.9 degree API gravity. The price can fluctuate with Kuwait crude oil F.O.B. Freight charges were fixed at the rate of $6 per long ton.

★ *Let thy speech be better than silence, or be silent.*

—Dionysius, the Elder

Energy Supremacy: IPAA Manifesto

An original offense in public relations was taken by the IPAA in launching what it terms an industrial manifesto urging cooperation of all energy resource industries in interpreting their problems to the public and to government. If you haven't received a copy of the booklet entitled "Energy Supremacy: Symbol of Security for America," we suggest you write to Independent Petroleum Association of America, P. O. Box 1019, Tulsa 1, Oklahoma. They will send you a copy upon request.

★ *A woman's promise to be on time carries a lot of wait.*

You Name the Title

For this piece we'll leave the head-writing to you. We give up. In the January issue of *The Petroleum Engineer* (A-31) Randolph Van Nostrand discussed the question of whether company magazines should combat union propaganda favoring government enterprise. The first letter was received from a mechanical and industrial engineer in Alameda, California:

"Regarding your article in *The Petroleum Engineer*, I think your proposal of publication of management views in employee publications is a good idea if done on a voluntary basis. However, I am wondering if you would be kind enough to give me your views, or tell me what you think is the difference between the Big Brother government of the unions and the subsidies handed out to business of all sorts providing they are powerful enough to get in on the subsidy racket, such, for instance, as the 30 percent write-off to the oil companies, and I do not know of a single big business in the United States that is not getting a subsidy of some sort, however it may be disguised.

"As long as our business leaders maintain such a janus attitude toward the public, how can they expect to be taken seriously in the matter? As a matter of fact, labor is a Johnny-come-lately in the subsidy game. One of our economists, writing at the time of George Washington, says the business of that day expected and received subsidies, starting with but not ending with postal subsidies. We inherited the practice from Great Britain.

"Personally I am not in favor of a government grant to anyone; let agriculture and business hoe their own rows; however, if we give it to one group, all groups should be treated on equal terms."

G. J. Cummings

Here is the answer from the director of public relations of Merchants and Manufacturers Association:

"Dear Mr. Cummings:

"Thank you for your letter of January 20, regarding my article in *The Petroleum Engineer*. I am happy that you thought that publication of management views in the employee publication is a good idea.

"I am afraid I don't see close connection between the operation of labor unions and government subsidies. I suppose that if we completely believe in the free market, subsidies of all kinds should be eliminated, but I am afraid that actually we live in a 'mixed' economy.

"There is one point which I would like to comment. If by a 30 percent write-off to the oil companies you are referring to the depletion allowance, then I must take issue with you because as you very well know, the search for new oil reserves is very costly and there are very many more dry holes bored than actually hit oil.

"There has to be some incentive for wildcatting.

"Moreover, every time a company sells some oil or gas, it is actually reducing its capital, and this is the story of all extractive industries."

Randolph Van Nostrand

It's Higher Than You Think

In the 1960 budget (which weighs four pounds) expenditures for the Federal Government are listed at $77 billion and receipts are expected to be around $77.1 billion. This amount doesn't take in quite everything, though, when actually total expenditures to the public are listed as $92.9 billion and total receipts as $93.5 billion. When you get up that high who's even going to know whether or not they are balanced until it's far too late to do anything about it.

★ *Some people never get interested in anything until it is none of their business.*

Europe's Outlook

Bankers of 19 nations in Europe provided a statement on economic conditions in their countries for the First National Bank of Chicago. These have been translated and published in a booklet for use of American business men and investors. The comments will interest oil operators with European investments.

HIGHLIGHTS ★ ★ ★

Digest of News and Comments

Gulf Claims 'Featherbedding'

Gulf Oil Corporation claims that employee featherbedding is the real issue behind the current strike at its Port Arthur, Texas, refinery — not a 5 percent increase in wages. Management of the company states that it will give the wage increase, but would insist that new contracts include a provision stating that employees were expected to perform minor tasks outside their normal job classifications when necessary to complete their work. Gulf stated that it would not "hand out to organized labor the right to dictate how a refinery shall be operated." OCAW spokesmen, representing the Port Arthur refinery workers, claim that if this were so, the company could file charges against the union under the Taft-Hartley law.

Oil's Half Dollar

Titusville, Pennsylvania, Congressman Kearns has submitted a bill to congress that would call for the coinage of a new 50-cent piece commemorating the oil centennial. The proposed half-dollar would feature the likeness of Colonel Drake, father of the oil industry, or a derrick similar to that which he used in drilling the first well at Titusville.

Shell Raises Retirement Age

Shell Oil Company has increased the retirement for all employees not represented by labor unions to 65. When Shell began its retirement program in 1938, the age was 60 for men and 55 for women; during World War II, rules were changed so that employees could work until age 63 by invitation. Two years ago, rules were changed so that they could either retire automatically at 60 or stay under their own initiative.

Socony, Others Build Reactor

Ten companies in a joint venture, operated as Industrial Reactor Laboratories, Inc., have constructed a large nuclear research reactor at Plainsboro, New Jersey. Now in operation, the $4,500,000 reactor and supporting laboratories will be used in the participating companies individual research programs. Included are Socony Mobil Oil Company, American Machine & Foundry, American Tobacco, Atlas Powder, Continental Can, Corning Glass Works, National Distillers & Chemical, National Lead, RCA, and U. S. Rubber.

Scots Make Gas from Coal

Construction has begun on facilities designed to give Scotland 30,000,000 cu ft of gas a day from its large — but poor quality — non coking coal beds. Coal will be transported by conveyor from the open cast field to a plant utilizing the Lurgi process, where gas is made by the reaction of coal with steam and oxygen. Involved in the $21,585,000 project is the construction of an oxygen plant and 133 miles of pipeline to be laid throughout the Scottish industrial belt. Construction of the first phase is scheduled to be complete by autumn of 1960.

Technical Societies to Register At Petroleum Engineer Booth, IPE

Registration of engineers and other technical personnel at the coming International Petroleum Exposition, Tulsa, will be handled at *The Petroleum Engineer* exhibit booth. Organizing machinery for the mass registration are 16 cooperating technical societies.

Cooperating in the effort are: The American Institute of Electrical Engineers, American Chemical Society, Tulsa Geological Society, American Society of Metals, American Society for Quality Control, American Society of Heating and Airconditioning Engineers, Society of Exploration Geophysicists, Society of Automotive Engineers, American Institute of Chemical Engineers, American Society of Tool Engineers, American Society of Mechanical Engineers, American Institute of Industrial Engineers, American Association Petroleum Geologists, American Society of Safety Engineers, and the Engineers Club of Tulsa.

Imports 'Unit Effort' Asked

President of the Independent Petroleum Association of America, Gordon Simpson, has called upon producers of coal, electricity, natural gas and atomic energy to join in a united effort against the "twin threats," which he defines as government control and big oil company domination. The plea was voiced through a new nationwide public relations campaign. Among other things, Simpson pointed out problems common to coal and oil producers — the rising flow of foreign oil imports — and recommended a 1,500,000 bbl per day crude and products limit.

Treasury Sec'y Favors 27½%

Treasury Secretary Robert B. Anderson has told the House Appropriations Committee that reducing the oil depletion allowance as a means of gaining additional tax revenue would be undesirable. Anderson said the allowance has to be appraised in the light of the national policy affecting the development and preservation of natural resources, as well as a part of the overall tax structure, and told the group that the allowance functioned "pretty well" in maintaining adequate oil reserves.

Phillips Forms Foreign Unit

Phillips Petroleum Company has formed a foreign sales and development department, to be headquartered in New York City with John Getgood as manager. The new department will initially engage in world-wide sale of crude oil, but will ultimately handle the sale of all Phillips products, patent licenses, technical services, purchase and resale of oil products, and development of manufacturing, distribution and sales projects outside the U. S. and Canada.

D-X Sunray Adopts New Seal

A red, white, and blue symbol has replaced the familiar red, cream, and black sign that D-X Sunray Oil Company has used for the past 25 years. The company, marketing subsidiary of Sunray Mid-Continent Oil Company, is placing its new signs at 8500 service station outlets in its 17-state mid-western and mid-south territory. The change will affect all cans and cartons of D-X products, gasoline pumps, advertising, etc., as well as trademarks used in production, exploration and refining operations.

IPAA Issues Manifesto

To guarantee "energy supremacy" for the U. S., fuel and power resources must join together to increase quantity through exploration and development, and quality through research, and must keep in reserve an up-to-the-minute energy package as a deterrent to war or aggression, says the Independent Petroleum Association of America. The IPAA has issued an "Industrial Manifesto" whereby it pledges a 10-point program designed to maintain energy supremacy for the U. S.

SCRUBOSPHERE*...

- The **dust removal ability** of the SCRUBOSPHERE **is superior** because it utilizes wetted surfaces for dust collection which are much more closely spaced than in conventional equipment.
- **Oil loss is minimized** because the oil used to wet the dust collecting surface is lifted mechanically instead of bubbling gas through the oil which results in foaming and loss due to creation of hard-to-separate fine particles.
- **Maximum performance and low cost** — The spherical design means high capacity and performance because it provides maximum dimensions for the contactor and mist extractor which normally are limiting factors in scrubber designs. The vessel cost is reduced because required vessel thickness is only one half that required for cylindrical vessel of same diameter.
- **Versatility** — separates solid and liquid particles with equal efficiency.
- **Low pressure drop** — ½ to ¾ psi at rated capacity depending on nozzle size.

PEERLESS MFG. CO. DALLAS TEXAS

PEERLESS MANUFACTURING CO.

P. O. BOX 13165 DALLAS, TEXAS

Representatives in All Principal Cities

Write for test data showing dust removal and oil loss of Peerless Scrubosphere as against conventional dust scrubber.

OVER 20,000 SEPARATORS and SCRUBBERS IN SERVICE"

Oil Product Prices Up

Strong upward movement of prices for most oil products was noted during February despite winter's end and a seasonally sluggish gasoline market. Fuel oil and kerosine costs were expected to see one more increase before heating demand declines. Gasoline prices, usually stable during the waning winter months, are being raised in some parts of the U. S. Industry observers cite a growing trend to pass on to the public the recent 5 percent wage boost afforded many petroleum workers.

Bolivia Forms Little 'API'

The Instituto Boliviano del Petroleo (Bolivian Petroleum Institute) has been organized with headquarters in La Paz. Activities of the institute, to remain in the technical and scientific fields, will be directed by Alfonso Romero L. as president. Romero is general manager of YPFB. Vice president of the new organization is Benjamin Hake, general manager of Bolivian Gulf. Secretary is Enrique Mariaca B., assistant to the general manager of YPFB, and treasurer is Fernando Ortiz S., public relations, Shell.

Signal-Bankline Merge

Directors of Signal Oil and Gas Company and Bankline Oil Company have voted to merge the two firms in a 1-to-5½ share stock exchange. Stockholders have yet to ratify the merger. Signal is to be the surviving corporation. Signal's operations will be expanded by the addition of Bankline's reserves, marketing outlets, a 10,000 bbl per day refinery, and 1500 bbl per day oil production.

Naval Petroleum Reserve Disposal

A bill has been introduced in the U. S. Senate to place 40,000,000 acres of land into the hands of the Department of Interior. The land, now the four existing petroleum reserve areas of the Navy, would then become available for leasing under the Mineral Leasing Act. The bill, introduced by Sen. Joseph O'Mahoney of Wyoming, was at the suggestion of President Eisenhower in his recent budget recommendation message to the 86th Congress.

Haight Leaves Creole Post

H. W. Haight has been elected chairman of the board of directors of The Carter Oil Company, and has resigned as president and a director of Creole Petroleum Corporation. Both companies are subsidiaries of Jersey Standard. Haight, in Venezuela since 1945, was president of Creole since November 1954. Carter Oil's president, John W. Brice, will continue in his present capacity as chief executive officer of that company.

Conoco Forms Dutch Company

Continental Oil Company (Nederland) N. V. has been formed as a subsidiary of Continental Oil Company. The new firm, with offices in Rotterdam headed by J. R. Cowell, will promote European sales of Conoco's refined products, with special emphasis on petrochemical and specialty products. Formation of the new subsidiary follows closely the recent establishment of Conoco's foreign department office in New York.

Titusville 'Birthday Party' Planned

Plans are being made for an oil industry "birthday party" at Titusville, Pennsylvania, where the oil industry was born 100 years ago this August 27. A non-profit corporation has been formed to sponsor appropriate centennial year ceremonies and to call public and trade attention to the events and to the significance of the year. Complete plans for the industry-wide program will be announced soon, says Harry A. Logan, Jr., president of United Refining Company, Warren, Pennsylvania, chairman of the oil industry division of the centennial group.

Joe Webb Refining Engineer Editor

J. C. "Joe" Webb, formerly consulting chemical engineer of Houston, Texas, has been named editor of *Refining Engineer*, a specialized edition of *The Petroleum Engineer*. He was graduated with distinction from Oklahoma State University (formerly Oklahoma A&M) in 1951. From June 1951 until September 1955 he worked for Dow Chemical Company as production supervisor, design engineer, process engineer — the last two years as project engineer. Since that time, he has been associated with C. F. Braun & Company in California as project chemical engineer; Brown & Root, Inc., Houston, as assistant to project engineer; and with Wyatt C. Hedrick Engineering Company as a senior project engineer. For the past year, he has managed his own consulting firm of J. C. Webb and Associates of Houston.

His experiences include: Refinery, petrochemical and inorganic process design; determination of process flow and mechanical requirements; specification of materials and equipment; economic studies, estimating; job scheduling, personnel supervision; plant studies; maintenance problems; construction and start-up. He is a registered professional engineer in Texas, No. 12351. His headquarters are at the company's Dallas office from where he will manage all editorial functions of *Refining Engineer*.

Drilling Costs Down in '58

Average total drilling costs per foot decreased from $13.60 in 1957 to $13.25 in 1958, reports the American Association of Oilwell Drilling Contractors. The annual tabulation of drilling and costs data revealed that total active rigs decreased to a 10-year low of 2086 (average) monthly in the past year. Total number of wells drilled, off more than 5000 from the previous year, were shallower on the average, by 72 ft. The AAODC believes that lower drilling costs were due to the drilling of fewer exploratory wells, slight modifications in some casing programs, a lesser average well depth, and an improved rate of penetration.

Foreign Oil Prices Fall

Middle East and Venezuelan crude oil prices have fallen recently as a result of too much oil and too little market. In the Middle East price concessions are becoming commonplace, and in Venezuela the largest producer, Creole Petroleum has reduced its prices as much as 15 cents a bbl. Creole reduced its postings following the decrease announced by Shell in that area. Creole spokesmen cite increased production from fast-growing producers within Venezuela and increased competition from Middle East oil companies.

Spain Eases Oil Rules

As much as 100 percent foreign ownership of oil companies operating in Spain is now permitted under a new Spanish law. The law, aimed at developing petroleum resources in Spain and its possessions in Africa, marks a basic policy change in oil legislation in that country. Oil regulations are to be issued in April, and permits for exploration under the new rule will be issued 20 days thereafter.

Good Wells Make Good News

A Monthly Report on Wells That Are Now Worth More

March, 1959

Here are results of some recent fracturing treatments performed by Dowell, using three of Dowell's ten basic fracturing services.

- **Lea County, New Mexico** (New Oil Well) Pay zone was the Grayburg sand between 4190 and 4209 feet. On initial test there was no production. After a 500-gallon regular acid treatment, well tested only a show of oil. Operator ordered Sandfrac®, using 20,000 gallons refined oil with 40,000 pounds sand. Injection was down casing at 20 bpm and 2900 psi. After clean-up, well tested 300 bopd. Other wells in the area treated with only 10,000 pounds sand have tested only 135 bopd.

- **Bossier Parish, North Louisiana** (New Gas Well) This well made only a show upon completion. Perforations were from 6233 to 6244 feet into the Travis Peak sand. Operator suspected that loss of mud into the formation was blocking production. He had Dowell acidize with 1500 gallons Mud Acid, after which well flowed 460 mcfd into line. To increase production further he ordered Stratafrac®, using 3500 gallons acid-kerosene emulsion with 2400 pounds sand. This was followed by 500 gallons Dowell acid with a silicate control agent added. Over 60 days after fracturing, well was still delivering 1516 mcfd to the line.

- **Clark County, Illinois** (New Oil Well) This well, completed in a 15-foot section of the tight Trenton lime, made only a show of oil and gas. Operator ordered Riverfrac®, using 155,000 gallons water with demulsifying agent and 20,000 pounds sand. 150 pounds temporary plugging agent were also used. Injection rate averaged 40.6 bpm at 1800 psi maximum pressure. After clean-up, initial production was 70 bopd flowing.

- **Liberty County, Texas Gulf Coast** (Old Oil Well) This well was dually completed into two sections of the tight Frio sand. Perforations were 8944 to 8971 and 9013 to 9068 feet. Production had declined to 40 bopd. The operator decided to fracture both zones separately and ordered Stratafrac. The lower zone was isolated and fractured with 6000 gallons fluid and 10,000 pounds sand. Then the upper zone was isolated and fractured with 6000 gallons fluid and 15,000 pounds sand. After both zones cleaned up, production from the lower sand stabilized at 45 bopd and from the upper at 55 bopd. This was a net production increase of 60 bopd and the entire treatment cost was paid out in less than two months.

Your Dowell representative can help you select the best treatment for your well. If fracturing is indicated, he can help you decide treatment size, the fluid to be used, amount of sand, injection rate, etc. For detailed information or prompt service, call the Dowell engineer in your area. In Canada, contact Dowell of Canada, Ltd.; in Venezuela, United Oilwell Service. Or write Dowell, Tulsa 1, Oklahoma.

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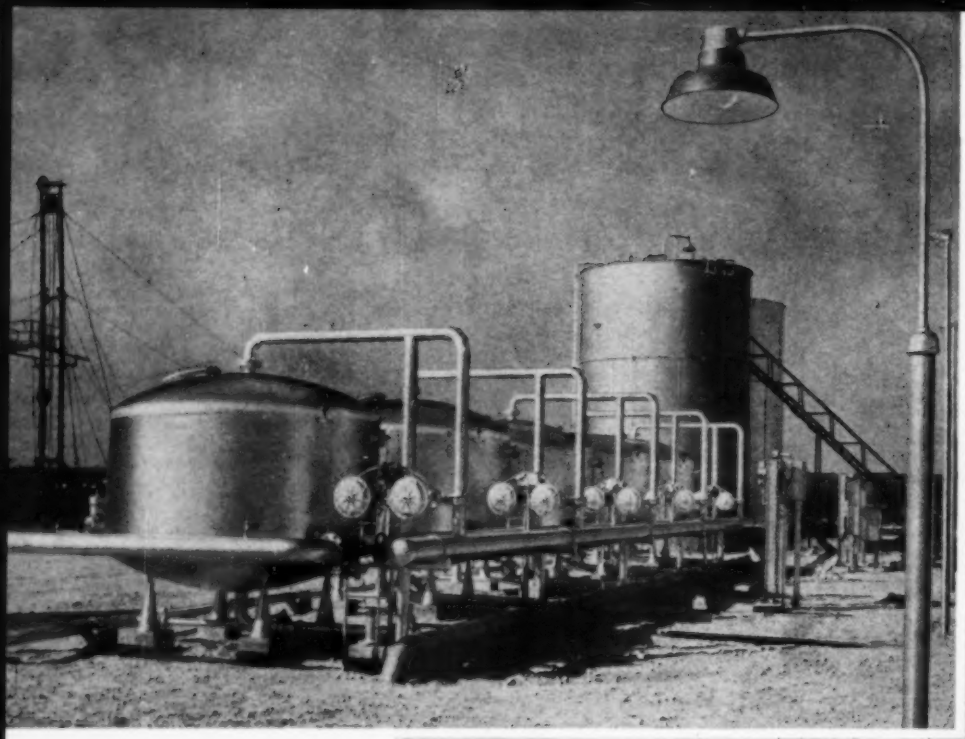

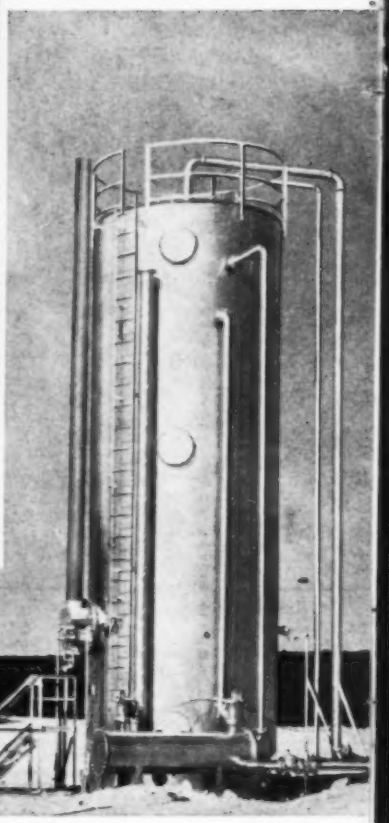

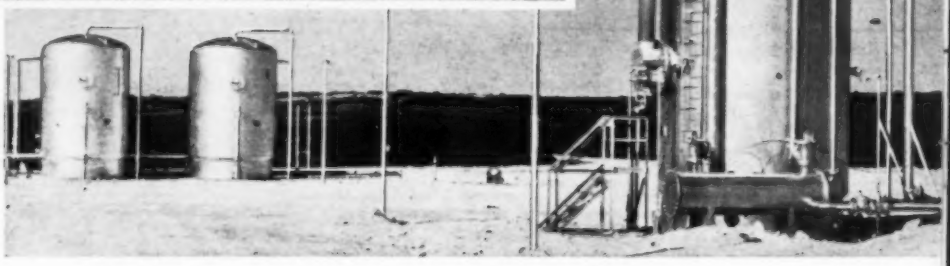

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In this system, production water from the treater and the free water knockouts is combined with "source water" from 2 750-bbl. tanks (fed by 2 water wells), and is pumped through the filters to the injection pumps, and thence into several injection wells.

The 5 filters are controlled by a preset time clock on a cycle that keeps some of them on stream while others are on automatic backwash. The piping manifold on the filters and twin valves is so arranged that when the time clock closes the inlet valve, it opens the other valve starting the backwash cycle.

This installation is a good example of BS&B "Oilfield Automation" at work. Why not let your BS&B Man help you put your operations on an automated basis, too?

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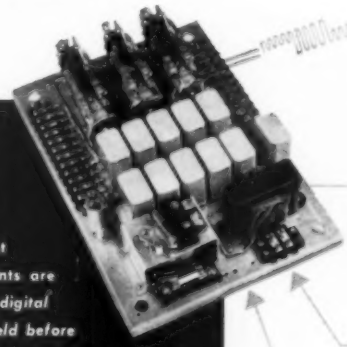
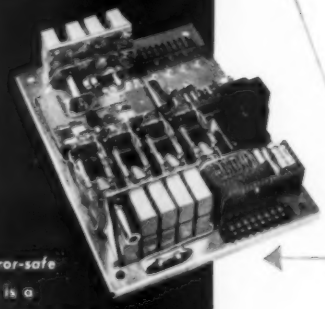


FIELD SELECTOR UNIT has 100 point capacity. Points are identified *in digital code from field before control power is actuated.* Matrix power wiring allows 20 wires to connect 100 points.



ANALOG INPUT UNIT to generate *error-safe* digital output, is a self-balancing, three-decade (0.1% accuracy) Wheatstone Bridge.

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Dresser Turbodrill, Security bit pattern and casting "hot pour" are combined in composite design at the left. These tools of drilling are dynamic components of the petroleum industry. The complex task of drilling calls for special skills using products designed and engineered to meet exacting requirements for boring many thousands of feet into the earth. In drilling, Dresser equipment and technical services have become the standard of comparison throughout the world.

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C. E. Williams, Gulf Sales Engineer, Midland, Texas, and G. W. Ramsey, Assistant Plant Superintendent, inspect force feed lubricators on one of the modern gas engines at the Goldsmith plant of El Paso Natural Gas Company.

No lubrication problems in 8 years of operation

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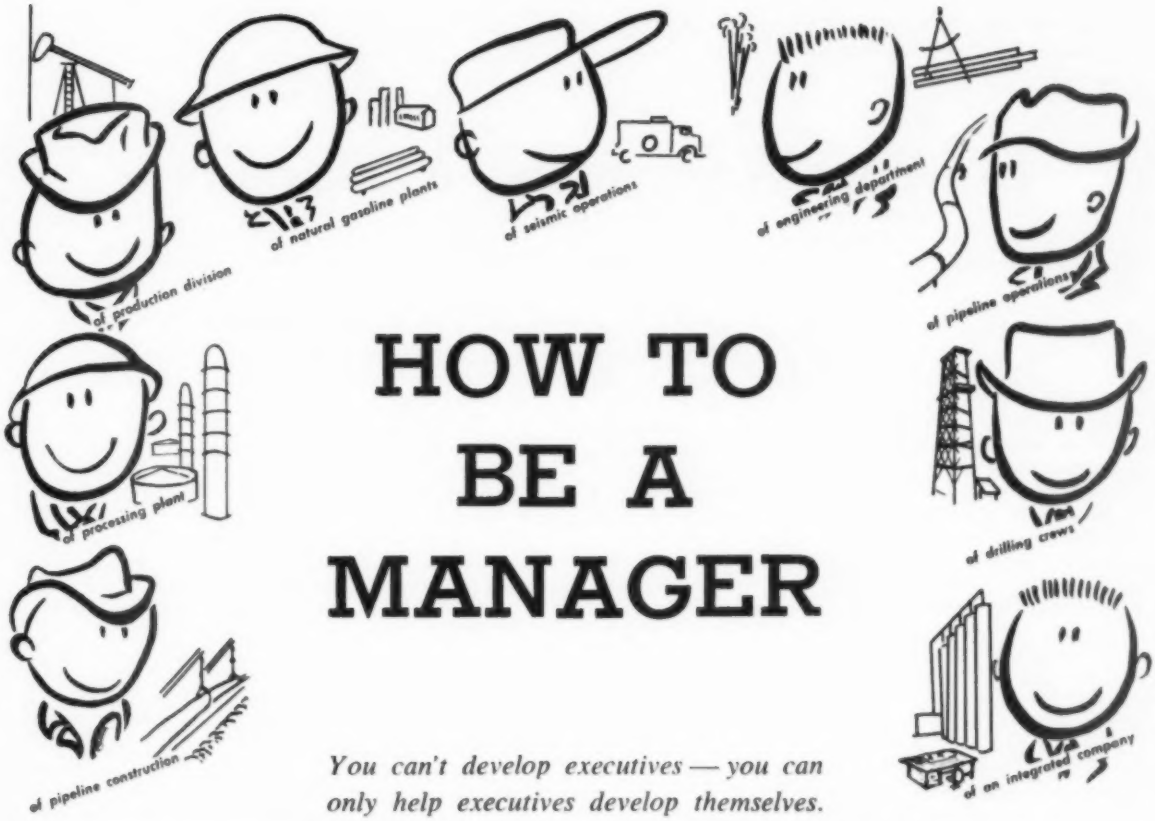


HOW TO BE A MANAGER

You can't develop executives — you can only help executives develop themselves.

OUTLINE FOR CAREER PLANNING: 40 SIGNIFICANT OBJECTIVES

HAVE A GOAL

1. Do you want to be a manager?
2. Do you have what it takes to be a manager?
3. Do you know the functions of management?
4. Where do you want to be in 1 year? 5 years? 10 years?
5. Do you want to work to gain management objectives?
6. Do you have a philosophy for your working life?

KNOW WHAT IT TAKES TO GET THERE

7. Vision to understand and courage to act.
8. Human relations.
9. Why do people act that way?
10. Basic guides to influencing others.
11. Think about those below you, too.
12. Delegation affects you and others.
13. Understand job just ahead.
14. Don't overlook lateral changes for enlarging your experience.
15. Could your present job be improved in status?
16. Identify your shortcomings for the next step.

PREPARE FOR PROMOTION

17. Read and remember.
18. Take correspondence or night courses.
19. Do on-the-job training.
20. Work on general education as base.
21. Take management courses.
22. Consider sabbatical year for degree.
23. Learn to write effectively.
24. Make speeches.
25. Sell your ideas.
26. Learn how to make decisions.
27. Study how to conduct conferences.
28. Do community work.
29. Evaluate your political views.
30. Gain and keep your family's support.
31. Care for your health.
32. Watch your finances.
33. Learn to choose wisely in business vs personal interest.
34. Keep yourself sold on what you are doing and keep your boss sold on you.

REVIEW AND REVISE (AUDIT)

35. Use check lists periodically to evaluate your development.
36. Study your job. Does it contribute to your career?
37. Are you in a job position box with no way out?
38. Are you compatible with your work?
39. Could man below fill your spot if you get a promotion?
40. Plans of your days and your years change with circumstances. Keep them flexible without being intangible. Go over your daily schedule, your monthly program, your five-year plan. Keep them up to date. Put each plan in line with your goal and keep your goal in clear view.

HOW TO BE A MANAGER

Chapter One

Do You Want to be a Manager?

Ernestine Adams

"The greatest weakness in the Federal Government's personnel is inexpert managerial direction." — Hoover Commission

DURING WORLD WAR II a vice president and large shareholder of a corporation was caught at the high edge of an increased age-limit in the military draft. Although he had the opportunity to be an officer, he decided to go in as a buck private and recuperate from the hardships of management in wartime.

Before three months were gone the U. S. Army and the executive had both had enough. He was freely returned to his company, which did some defense work, and his army unit returned thankfully to unquestioned, hallowed routine.

He was a good vice president. As a GI he was an obstructive, disruptive force.

Some people like to be managers, work to be managers, and manage successfully.

Others do not want the responsibility, are not attracted by the prestige and when thrust into the position are unhappy or unaware and fail to perform.

The demand for managers is strong now and it continues to increase. Our well-being depends more upon management than any other vocation. As companies and the economic system grow in size and complexity, the need for astute executives multiplies. The basic resource needed for economic development is the ability to organize men into an effective group to provide goods and services.

One reason for the growing demand for managers with knowledge and initiative is the trend in decentralization of large corporations. This move helps not only to make local management more efficient but also takes the load off top management and gives the executives a chance to think and plan for effective overall operation and growth. The decentralized organization obviously requires more competent local managers.

At the present time, because of management shortage, there has grown up a service management business of huge portions. (One chain of management service has 11 units from coast to coast, one in Canada.)

Another form of meeting the demand is the expanse of management development courses established in universities and colleges across the country to force-feed potential managers — to get them ready more quickly to take on management responsibilities.

This material on "How to be a Manager" is not directed so much to you as a part of the company organization, but to you as an individual. After all, it is your decision to make — whether you will be a good manager and how you will go about it.

Within limits you can choose the route of your career.

You can decide whether you want to devote your chief effort to the technological phase of the petroleum industry and progress up the *staff* side or if you'd rather advance along the *line* or administrative side and be more concerned with broader company objectives.

You can decide whether you want high responsibility and

Miss Adams is Management Editor.

Advantages and Disadvantages of Being a Manager.

PRO	CON
1. You find a widened horizon — and greater prestige as a manager.	1. *A good manager operates so quietly he gets small credit.*
2. You are better paid and usually have more pension and benefits.	2. *Income taxes higher. Salary often less in proportion to effort.*
3. Have more opportunity to make interesting friends, meet stimulating people.	3. *Have less spare time for family or friends.*
4. Top spots are hard to fill so there's better chance near top.	4. *Even one rival for the position makes it a battle royal.*
5. Your responsibility to yourself is to develop and grow in stature.	5. *It is a lot simpler and sometimes more fun to be a lotus eater.*
6. You can provide a better environment to advance your specialty.	6. *You must lean over backwards not to favor your specialty and you lose touch with it.*
7. Bigger area for personal satisfaction.	7. *A lonely occupation.*
8. Better opportunity to develop individuality.	8. *To be successful you've got to eat, sleep, work on problems.*
9. Satisfaction of accomplishment or progress.	9. *Always wonder what wasn't done — never have a feeling of completing your work.*
10. Certain independence of thought and freedom of action.	10. *Responsibility often exceeds authority.*
11. You learn to make decisions and execute plans into actions.	11. *Requires objectivity — sometimes decisions distasteful to others.*
12. Better opportunity to aid others in their efforts.	12. *Always on display before subordinates.*

aim for top management or whether you'd rather spend your interest and energy on scientific engineering problems and manage groups of staff personnel. Sometimes you start in one way and end up another. William Kelly Warren began in a limited field — the first one to specialize in natural gasoline. But his company reached into other departments and was valued at about $80 million when sold to Gulf Oil Corporation. Warren is still chairman of the board and executive officer of Warren Petroleum Corporation, as well as a director of Gulf. He is one of many top management men whose interest and development have broadened from a specialty to overall command of a diverse organization.

"The two kinds of employed professional," writes Peter Drucker, "—the professional specialist and the professional manager — are mutually dependent on one another. They must exist and work together to be effective at all. The same man may do both kinds of work in his job; but the two functions are different and distinct."[7]

Actually, the question in the title of this chapter is purely rhetorical. Nearly every reader of this magazine is a manager or a potential manager in the petroleum industry. You may manage one person or 20 or 1000. You may have staff or line responsibility. Nevertheless you are a manager or you will be.

The question can be more accurately stated: "Do you want to be a *good* manager?" No matter where you stand you need managerial skills to work with other people, to promote your ideas, to achieve the greatest benefits from your career. You'll be a better employee if you understand the objectives of your company and know your place in the operational set up regardless of how far your managerial duties extend. The table on the preceding page gives you the pros and cons of taking on management responsibilities.

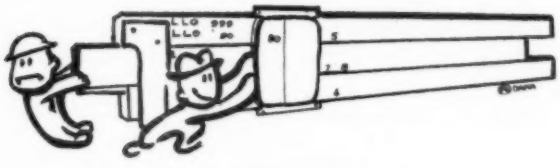
Everybody who writes or speaks about managers tries to describe what they are and what they do. Seldom are two explanations alike because management deals with intangibles that are barely recognized — much less standardized.

Crawford H. Greenewalt, president of E. I. du Pont de Nemours and Company, tells about an interview with a young lady who was preparing a college thesis on management duties. She asked what he did all day and he had difficulty in answering. "The more I thought about it," he said, "the more I was impressed by the fact that, in the executive area, there is no fixed procedure, no precise pattern, no yardstick of performance which can be counted and measured."[1]

John R. Suman, formerly vice president of Jersey Standard, says "A good executive must be solidly grounded in the skills of management. These skills may be relatively few or quite numerous, but some are more important than others — some are basic to the management profession. In most cases these vital skills can be broken down into three broad categories: Technical skill, human skill and conceptual skill."

TECHNICAL SKILL

In the petroleum industry technical skill in itself can be very complicated. It usually includes (1) Knowledge of science or engineering, of law, accounting, public relations, or medicine and (2) understanding of managerial methods to keep the specialized techniques in operation.



Managers are professionals, too.

A high level combination of professional and managerial skill is vital, for instance, in exploration operations. The success of Douglas Fyfe of Cia. Peruana de Petroleo "El Oriente" S. A. is largely owing to his ability to direct and encourage men in hazardous situations. He has discovered the only two fields in Eastern Peru. He needs all his geological knowledge in the jungles but he is called "Mr. Petroleo" primarily for his capacity to manage not only in the office but in the field.

Howard Pyle, president of Monterey Oil Company (and an engineer) says his company is made up mostly of professionals. This is not unusual for petroleum companies. Exploration, production and refining departments — legal, economics, health, public relations departments — all are manned by professionals. These professionals have had to learn executive techniques to become the management of the petroleum industry.

Mr. Pyle's statement gives emphasis to a significant trend in the petroleum industry — the growing number of scientists and engineers who advance to top management. Some look with alarm upon this fact, feeling that much technological knowledge is wasted. Management, however, can use specialized skills as well as general knowledge. Also it seems that brainpower is needed more in management right now than in specialized technological departments. Our processes and machines have outraced our knowledge of people, the most essential part of business operations.

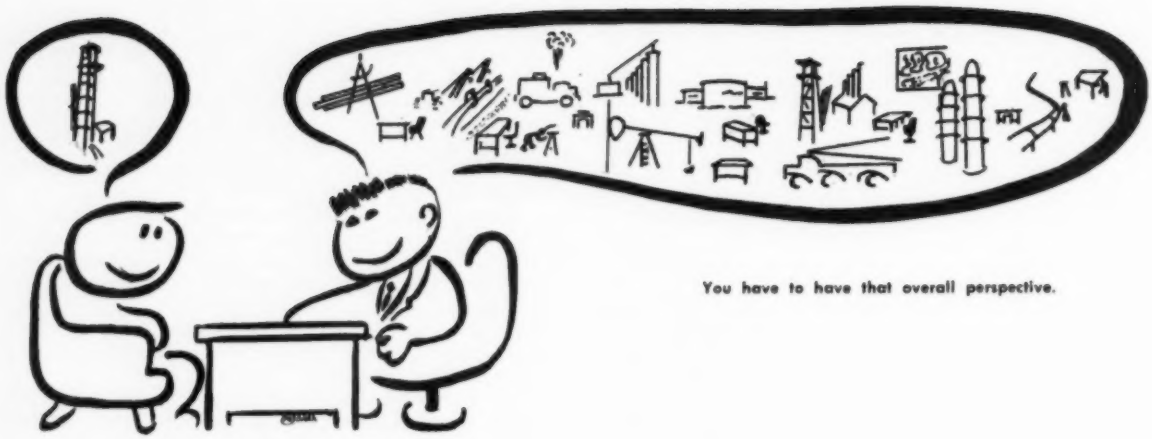
You can't make him drink.

HUMAN SKILL

The most hit-or-miss skill is that of human relations. The word "manage," once meant "handling a horse" and somehow this gives us a clue to human relations in business. Coercion is no good. "You can lead a horse to water but you cannot make him drink."

The historian, Arnold Toynbee, writes: "In spite of his pride of Intellect and Will, Man has, for his self-preservation, to find some way of coping with . . . the Human Psyche,"[2] which, he adds, is still untamed and cannot be tamed by force.

Human skill deals with a mysterious force we are scarcely able to comprehend much less to develop. We do well, really, to recognize the results of human skill. In Dr. A. Q. Sartain's "What Makes a Man Work"[3] he explains some common reactions to skillfully managed human relations



You have to have that overall perspective.

but he admits "relatively little is known as yet about how to get the best from another person."

In my experience there is one inevitable quality of a good executive — he evokes enthusiastic loyalty. Only once did I get a negative response concerning a top executive in the petroleum industry and the reason was easy to find. The comment came from an officer who had been publicly belittled by his chief.

This incident stands out — though it happened long ago — because it is so unusual. A good executive builds the morale of his staff by appreciation of their efforts. Robert L. Minckler, president of General Petroleum Corporation, says facetiously — "When I walk down the halls and see anybody working, I go in and tell them they're doing a good job."

This is almost true and it produces better jobs than the good ones he praised.

Yes, a good executive must have human skills. At this stage in our development it is more talent and art than an acquired accomplishment.

CONCEPTUAL SKILL

We often hear people talk about specialists and generalists with the idea that a chemical engineer, for instance, is a specialist and a vice president in charge of planning is a generalist.

But, paradoxically perhaps, the generalist manager is a specialist, too, and he must have one very special quality — he must have conceptual skill.

When Joseph N. Pew, Jr., in 1908 went to work for the Sun Oil Company, he told his father that no clearly defined job had been given him yet. His father said "I can't give you a job — all that I can give you is an opportunity. You'll have to make your own job."

This is conceptual skill on the individual level. To envision your own job, your own use and the place of your job as an essential part of the whole operation is the beginning of good management.

Take a fresh look at your job right now. How long have you been there? Is it short term or long? Write down a list of what you like about it and another one of what you dislike. Do they add up for you?

Not only must you be able to analyze your job and your handling of it — to be a good manager you must have the vision to see the whole enterprise as one operation and to understand how it fits into the economy and culture of its environment.

One of Albert L. Nickerson's staff speaks of him as an "integrated" oil man. What he meant was that, although Nickerson was a marketing executive before he became president of Socony Mobil Oil Company, he thinks and acts with the whole company in mind. He is objective, unbiased and is cogniscent with the entire organization.

A man with Transcontinental Gas Pipe Line Corporation said that E. Clyde McGraw, the president, possessed the "talent of overall perspective." That is another way of describing conceptual skill.

The three skills — technical, human, conceptual — are broadly outlined. There are other essentials — an executive must have a steady desire to excel, must have the driving energy to accomplish, must seek continual self-improvement. You may have part of these as traits and all of them you can sharpen and develop if you want to. We have provided a general picture of the requirements of a manager. In other chapters there will be more detailed lists of characteristics and methods that can help you measure and develop your potential more fully.

Galileo said "You cannot teach a man anything; you can only help him find it within himself." We've paraphrased this to fit this series: "You can't develop executives; you can only help executives develop themselves."

Your interest in "How to be a Manager" is of high significance to you. Only you can use the methods — only you can make them work — only you can put together *your career.*

Did You Learn These Points?

1. Do you have any choice about being a manager?
2. What three skills are essential for managers?
3. Define "staff" and "line."
4. What did the word "manager" originally mean?
5. Would you call a manager a specialist or a generalist?
6. Have your abilities as an executive improved in the last year? Answer this today and a year from today.

You'll Profit by Reading . . .

[1]*Crawford H. Greenewalt, "The Uncommon Man: The Individual in the Organization", McGraw-Hill, New York, 1958.*

[2]*Arnold Toynbee, "A Study of History", Oxford University Press.*

[3]*A. Q. Sartain, "What Makes a Man Work",* The Petroleum Engineer, *Page E-1, March, 1956. (Copies available.)*

[4]*Harwood F. Merrill and Elizabeth Marting, Editors, "Developing Executive Skills", American Management Association, New York 1958.*

[5]*Joseph Dean Edwards, "Executives: Making Them Click" University Books, New York, 1956.*

[6]*"Petroleum Profiles", biographies of petroleum industry managers, published once each month in* The Petroleum Engineer, *Page A-8.*

[7]*Peter Drucker, "Landmarks of Tomorrow", Harper & Brothers, New York, 1959.*

HOW TO BE A MANAGER

Chapter Three

Do You Know the Functions of Management?

Wilson J. Bentley

"The future is the manager's province." — Anonymous

IF YOU WANT to be a manager, you must first consider what you'll manage. You have to know the functions of organization and the factors that go to make up the activity of managing. You must know the elements in the system that cause success or failure of an organization. You must have an understanding of these items to make a manager out of yourself or to aid others to become better managers.

Why do we have organizations? We form organizations because we can obtain benefits and goals impossible (or more difficult) to obtain alone. Broadly speaking, this is the sole purpose of organization. The phrase of a few years ago, "It takes two to tango," is not as flippant as it sounds!

What causes success or failure of an organization? Being a profitable organization is an obvious goal of all institutions. You must know what brings profits — or losses.

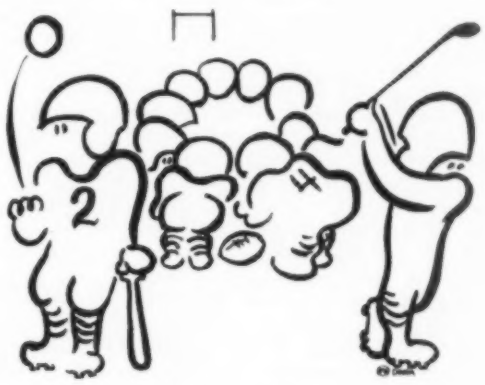
The results you can measure by mathematics but the methods must be painstakingly researched by observation. Take a manager like Raymond L. Tollett, president of Cosden Petroleum Corporation. He calls himself a "professional manager" and his success is measured in profits. The year he became president, late in 1940, the company lost $50,000 in operations and stockholders' equity was $3 million. In 1957 the company made $6 million, paid $2¼ million in dividends and was worth $33 million.

This is an example of clear-cut results, but it tells nothing about how it was done. To be a manager you must know what management is, what it manages and how it performs.

As is true of most commonly used words, the term "management" means different things to different people. Some people think of it as being that group of people who do not belong to the union. Others think of it as a small group of executives at the very peak of an organization. There are others who think of the term as representing some rather hazy group from which "all directions come." The word itself has come to signify a group of people. In contrast to this conception, I find it helpful to think of the term in another manner. *Management is the activity of maintaining the system of coordination of human activities.* It will be noted that this definition has one principal ingredient, and that ingredient is *human activities,* (or people). You don't manage machines or things, you manage human activities.

The phrase, "system of coordinated human activities," can be more simply referred to as, *an organization.* To promote the successful organization, it is necessary to have an understanding of the three principal ingredients that must be present. These three are: (1) Common purpose. (2) Willingness to serve. (3) Communication.

These ingredients must be poured into the pot somewhat simultaneously. There can be people who are, at least potentially, "willing to serve" (or cooperate) and there can exist a job which requires the cooperative efforts of people. Yet, without effective means and methods of communication, the ingredients are useless.



Too many objectives.

Professor Wilson J. Bentley *is head of the School of Industrial Engineering and Management at Oklahoma State University, Stillwater, which is also his alma mater. His department has an excellent and varied program of executive development courses for middle to top management personnel. He also serves in a consulting capacity to numerous industries in the field of management, organization, methods study and job evaluation. He has had a number of articles published on management and on drilling operations (several in this magazine).*

1. COMMON PURPOSE

Good synonyms of "common purpose," are *objective, goal, product of cooperation, and prospective resultant.* This first ingredient must be known and agreed upon by enough people to perform the necessary acts or the organization will never get started. In other words, "just what kind of a pie you're going to make" has to be known before anyone will decide to cooperate.

A young couple who once lived next door gave me my best example of this idea. It was the husband's habit upon reaching home from work to march to the front porch and swing in the porch swing until dinner was ready. The young wife was in the kitchen in the back part of the house preparing dinner. In these relative positions, they tried to carry on a conversation. The acoustics through their house were

such that neither one could hear the other very well, but (living next door) I could hear both of them perfectly.

One evening, I overheard him ask her what she was doing. After much yelling back and forth, the husband finally got the communication that she was making a pie. After more shouting, she got the message that he wanted to know what kind of pie she was making. By this time, she was somewhat disgusted with her husband and answered, "Just a pie!" His answer was obvious, "You just can't make any pie, you have to make some *specific* kind of a pie."

The purpose, objective, or product of cooperation, or prospective resultant must be known and agreed upon by enough people to perform the necessary acts for the organization to even begin to go.

As manager, then, you need to establish desirable and attainable goals and obtain those personnel to whom these goals will be acceptable and desirable.

He has to want to drink.

2. WILLINGNESS TO COOPERATE

This ingredient has many aspects to it. It is the area in which the manager applies all the leadership qualities which he can call upon to convince the personnel that it is to their benefit if they cooperate in the activities of the organization. To be a manager you must create faith in yourself on the part of your employees. If an employee does not believe that you have the ability to aid him in attaining his personal goals, then he will "check out" of the organization.

One observation which should be made is that the willingness-to-cooperate ingredient must occur almost simultaneously with the objective becoming known to the individual or the individuals. Have you ever had this experience? A man is invited over to one of his friend's house for a "little game of cards." Upon discovering that the "little game of cards" was to be a game of bridge instead of poker, he immediately declines the offer. This man found that the "common purpose" did not agree with his desires or objectives and he was no longer "willing to serve."

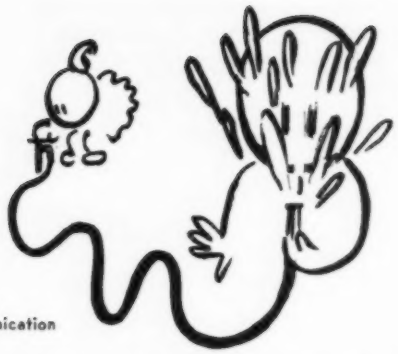
You'll find that each individual will compare (consciously or unconsciously) the incentives (or advantages to him) to cooperate here, some place else, or not at all.

3. COMMUNICATION

The third ingredient necessary to the formation and maintenance of an organization has been indicated but not actually pointed out. That is communication. You cannot be a manager if you do not or cannot communicate about goals of the organization to obtain people who are willing to cooperate. You cannot gain cooperation unless you can convince your people you can lead them to success.

After the goal is set and the people are in a cooperative state of mind, additional communication must take place to achieve coordination of the acts of these people in relation to the attainment of their objectives.

You say to them: Your job is to cook the hamburgers,



Insufficient communication in timing.

your job is to transport them to the consumer, and your job is to wash plates and glasses. This management activity tells individuals what their jobs consist of. Still this is not enough. These acts, which are to be performed by the individuals, must be coordinated.

The term, coordination, can be thought of as the contribution of personal acts to an organization that are appropriate as to time, place, and manner so as to augment the acts of others in the achievement of an objective. Cooperation (or willingness to serve) is the forerunner of coordination. But, no matter how willing the individuals may be to coordinate their acts, willingness alone will not achieve the end they seek. The acts of one person in relation to another must be fitting as to time, place, kind, and manner.

A classic example of this has happened to me as it does to most fathers. A few summers ago, after repairing the nozzle for my garden hose, I decided to try it out. My instruction to my 6-year-old daughter was to turn the water on when "I was ready." You know what happened. She followed my instructions, but did not determine *when* I was ready. I received a free wash job. There was "willingness to serve," "common purpose," "communication about the objectives," but insufficient communication on operations which resulted in rather poor coordination (at least from my viewpoint).

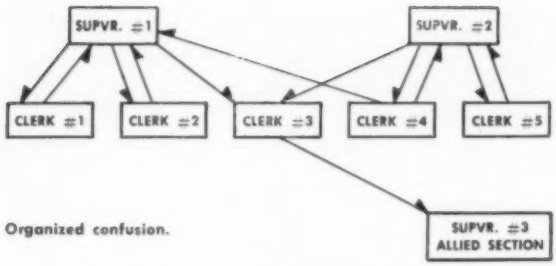
Your coordinative communications must, of course, follow planning, which is the preparation for managing.

When you are planning, you are forecasting, you are visualizing the changes you feel necessary to attain the objectives, you are visualizing the acts needed to accomplish the objective, you are visualizing the sequence in which these acts must be performed, you are forming a "before and after" mental picture of the job and the results.

You have to take under consideration at all times that the ultimate goal in organization is the net satisfaction of everyone that has anything to do with the organization. By "net satisfaction," I mean that benefits of the situation equal or outweigh the burdens. A part of this preparation of managing (or planning) includes the division-of-work or coordinative activity. As a manager your objective is to so manipulate the forces and affect the work climate that individuals produce more. For this you need thorough communications which are impossible without a good grasp of organization.

For instance, how can there be any efficiency of operation when there is confusion as to who reports to whom? An oil company with which I have consulted found a condition existing which they still cannot quite believe. A questionnaire was filled out individually by members of a small section consisting of two "supervisors" and five clerks. If the results were charted, they would look like this:

Clerks 1 and 2 find agreement on their relationships. Supervisor 1 says that he supervises Clerk 3. Supervisor 2 says that he supervises Clerk 3. But Clerk 3 says that he looks toward Supervisor 3 (who was supposedly not in the "picture") for supervison. Supervisor 3 does not claim to



Organized confusion.

supervise Clerk 3. Supervisor 2 says that he supervises Clerk 4 but Clerk 4 says that he receives orders from both Supervisor 1 and Supervisor 2. There is mutual agreement between Supervisor 2 and Clerk 5.

There have previously been all kinds of accusations "thrown" at this section, but no one ever wondered if the inefficiency could be caused by organizational relationship troubles. What was the difficulty?

Obviously, the difficulty was insufficient or ineffective communication by the managers involved. An organization chart, itself, will not solve the difficulties but it does start the activity of communication. An organization chart, basically, indicates the formal line of communication.

If there is any one of the three essentials of organization which is more important than the other, or which is a possible cause of effective or ineffective operations than any other, it is probably that of *communication*. A poor method effectively communicated will normally produce better results than a good method poorly communicated.

Jack A. Vickers, Jr., president of the expanding Vickers Petroleum Company of Wichita, Kansas, is one of the strong believers in the importance of communicating with the industrial community — inside and outside the firm. Vickers makes successful use of the committee system for intra-company communicative purposes. Decisions are still made by the responsible manager, but decisions are aided by a background of discussion with interested department heads.

As other able executives have done, Vickers has surrounded himself with able professional management personnel who compliment his own abilities. He still feels that good communication "just doesn't come naturally — you have to work at it."

One might define the act of communicating (by humans) as the activity by which information is transmitted by one person and received by another. A complete communication, then, consists of a message which is transmitted by one person and received and *understood* by another. The word, communication, can be thought of as including any and all procedures by which one mind may affect another. The ultimate goal of communication, then, is to influence the behavior of another person in a certain way.

Lawrence Appley, American Management Association, says that individuals will produce better when they know more about:

1. *What they are supposed to do.*
2. *What authority they have.*
3. *What their relationships are with other people.*
4. *What constitutes a job well done (in specific results).*
5. *What they are doing exceptionally well.*
6. *Where they are falling short.*
7. *What they can do to improve unsatisfactory results.*
8. *That there are just rewards for jobs well done.*
9. *That what they are doing and thinking is of value.*
10. *The boss' deep interest in and concern for them.*
11. *The boss' desire for them to succeed and progress.*

These conditions are the responsibility of the manager and require specific skills to bring them about. Now why not analyze this list and then examine the one below giving possible causes of monetary losses, or failure to produce.

Some causes of unprofitable conditions in organizations:

1. Poor product (seemingly the most obvious, but occasionally the last reason considered).
2. Economic conditions (local, state, or nation).
3. Lag in technological advancement.
4. Improper logistical, budgetary and financial planning.
5. Lack of control over wages, salaries and complement.
6. Lack of follow-up (of cost reduction programs, etc.)
7. Mediocre or improperly trained personnel.
8. Unassigned responsibilities.
9. Individuals not knowing what they are supposed to do.
10. Too much overlap of responsibility assignments.
11. Irritations between organization members.
12. Too many people to supervise.

Reviewing this list reminds me of something our family doctor said about the growth of a child both before and after birth. His statement was, "There are so many things that could go wrong with a child that it is a great wonder to me that normal adults ever happen." Looking at the above list of things that can result in monetary loss (and reviewing others not listed) would make a person wonder how a profit-making company ever "happens."

Of the 12 items on the 2nd list, all but the "economic conditions" could easily be placed under the general classification of management. So, there is no argument with the statement that profits can be obtained and increased by improvement in management.

The person who is in a position in which his principal activity is guiding the efforts of others, managing, must have both a broad and a deep understanding of human relationships in cooperative efforts. He cannot be completely successful and treat the "organizational wounds" superficially. He must get at the base of these wounds and treat them fundamentally. The activity of successful managing, then, requires a background consisting of the objective concept of management and organization fundamentals described in this chapter — and the ability to communicate to the constituents of the organization.

To be an effective manager, you must also be able to "see" the organization as a whole in order to properly evaluate the available alternatives which the manager might possibly advocate. You must not be one who thinks only in terms of techniques. You must be able to think in terms of the "whole"; you must think of management as "the activity of maintaining the system of coordination of human activities"; you must be able to analyze an organizational situation in terms of its three ingredients: (1) Common purpose, (2) Willingness to serve, and (3) Communication.

Only an understanding of the functions of organization will give you a sound basis for learning how to manage.

Can You Answer These?

1. What are the essentials of an organization?
2. What is the most important phase of the manager's activities?
3. Will having a bunch of "willing" people gathered together get the job done?
4. Will people cooperate without a "goal?"
5. What do you do when you are planning?
6. What are the conditions necessary for better individual production?

Here's Some Background Reading . . .

[1]*Peter Drucker, "The Practice of Management," Harper & Bros., New York.*

[2]*Ordway Tead, "The Art of Administration," McGraw-Hill, New York, 1951.*

[3]*Lyndall F. Urwick, "The Theory of Organization," American Management Association.*

[4]*Chester Irving Barnard, "Functions of the Executive," Harvard Press, 1938.*

[5]*Irwin H. Schell, "Technique of Executive Control, McGraw-Hill, New York, 1957 (8th edition).*

Canada's largest natural gas liquid extraction plant was placed in operation last October by Goliad Oil & Gas Company. Some 350 miles of pipelines gather casinghead gas from 290 tank batteries owned by 71 operators in nine gas conservation districts in Alberta's Pembina field. The plant conserves 85,000,000 cu ft of gas per day, manufactures 65,000,000 cu ft of residue gas for utility distribution, and recovers almost 200,000 gal of butane, propane, pentanes and iso-pentanes daily. — *Photo courtesy Bass Oil Company*

Canada Has Mixed Year . . . Prospects Uncertain

Crude oil output drops for first time . . . Borden Commission report presents hazardous proposals . . . Domestic demand rises 6% showing marketing strength is still advancing . . . Refining and pipeline facilities expand

H. G. Cochrane

ACCURATE ASSESSMENT of the prospects for 1959 are hazardous, because of the many "ifs" overhanging the future; implementation by Parliament of the recommendations contained in the first report of the Borden Commission; decisions by the United States on oil imports policy; rulings by the Department of National revenue at Ottawa on depletion allowance; decisions by the Alberta government on gas export; decisions by U.S. refiners in Pacific and Mid-West states on sources of crude supply; the impact of Venezuela's new "60-40" share of industry profits; and by willingness of investors to invest in the industry's future.

The optimists in the industry are looking for a great new era in expansion in oil, gas and by-product development. But the more realistic element is hopeful for a recovery of the loss in production experienced in 1958. They base their hopes on a modest further recovery from the recession and the hopes import quotas will be removed or replaced by some other form of control early in the year by the U. S.

Crude Suffers Setback

Canada's crude oil production in 1958 dropped below that of the previous year for the first time, recording a total of 165 million bbl, a 10 percent drop below the 182 million bbl produced in 1957. Thus came a break in the continuous 11 years of rapid expansion, which between 1947 and 1957 had raised the industry 25-fold into the nation's primary source of mineral wealth.

Alberta Suffered Most

Alberta, the province with the largest output of some 113 million bbl compared with 137.4 million bbl the previous year, showed the sharpest loss of 20 percent. Saskatchewan, with an output of some 45 million bbl, showed a gain of 21 percent over the 1957 production of 36.86 million bbl. Manitoba production at 6 million bbl showed little change from the previous year, while production from British Columbia and the Northwest Territories at 1.5 million bbl showed little change from the year before.

A factor which accentuated the poor showing for the year was the extra 7 million bbl of offshore shipments early in 1957 on the West Coast, which had distorted the first five months' output and was not repeated in 1958. The steady loss of pipeline markets in the Puget Sound area in 1958, however, which added up to a loss of some 14 million bbl during the full year, was the major reason for the sharp downtrend in Alberta production.

Domestic Market Steady

Though the domestic market remained strong on all fronts, with a rise of 6 percent, the overall decline was

due to the 42 percent drop in exports, mostly those to the West Coast. Transmountain throughput for the year showed a total of only 12.6 million bbl against 40.4 million in 1957. Exports from Saskatchewan and Manitoba together added up to 18.6 million bbl against 14.2 million in 1957 — a gain of 4.4 percent.

Net loss of export markets was thus 23.4 million bbl, which left a modest increase of 3.9 million bbl in Canada's domestic consumption of Canadian crude. This was primarily due to diversion of crude runs to Ontario refineries, wherever possible, from the Montreal refineries which operate on imported crude, mostly from Venezuela. It was also due to a changeover to domestic crude by the Sun Oil refinery at Sarnia, which heretofore had been using imported Mid-Continent oil.

Producibility Down

During 1958 Western Canada's oil potential or producibility remained steady at about 1 million bbl per day, with potential of new wells being offset by downward adjustments in MPR of older wells. But with adequate markets potential can be considerably boosted in 1959 from recent discoveries. During mid-1958 there were markets for less than half the potential and even less than a third in the spring, but average use reached 46 percent at the close of the year, compared with a U.S. average of some 70 percent.

Drilling

Though total completions for the year were down to some 2405 wells, 16 percent below the previous year's total of 2963, they were higher than in any year prior to 1955. The most noticeable difference to previous years was the reversal of trends in Alberta and Saskatchewan.

Alberta completions, at 1550, showed a 10 percent gain over 1957 while Saskatchewan completions at 800 were 35 percent below 1957.

Manitoba showed only 85 completions against 224 in 1957, while British Columbia and Northwest Territories at 75 completions showed a drop of 18 percent. Footage drilled of some 12.5 million ft was only 9 percent below the 13.8 million ft put down in 1957.

Exploration

Exploration activities were also curtailed. The year 1958 ended up with some 1100 crew-months for both oil and gas exploration, 20 percent below the 1389 crew-month total of the previous year and the smallest aggregate of work since 1949. The trend marks the inevitable decline in the number of new prospective areas to be explored as the western sedimentary basin becomes more nearly saturated with geophysical records.

Outstanding problem is now "muskeg," as wildcat activities move northward. Muskeg research is a dominant element in future exploration methods and policy. Vehicle development depends heavily on the research program for leads as to types of equipment suitable for use in muskeg, and already research has revolutionized methods of muskeg travel.

Crude Discoveries

Though 1958 was not an outstanding year for bringing in new oil pools of importance, quite a number of new finds were recorded which assisted in bringing reserves up to an estimated 4 billion bbl.

Best discovery during the year was in the Slave Point area in Northern Alberta where six oil accumulations have already been found in an area of 12,000 square miles. The Swan Hills-Whitecourt-Red Earth-Kaybob-Virginia Hills fields are all in this area. Activity was concentrated there during the 1958-59 winter.

Less Development Drilling

The steady trend toward wider spacing of wells, with minimum spacing of 80 acres in fields with good porosity and permeability, sharply cut the amount of drilling required to develop a given area. Likewise increased rig and crew efficiencies have reduced drilling time and hence the number of rigs needed. There was a 10 percent increase in active rigs in mid-December, mostly in Saskatchewan and Alberta.

Refining

Additions to crude refining capacity in 1958 totaled 61,000 bbl per day, most of it in British Columbia, Ontario and Quebec. Cracking capacity additions totaled 27,800 bbl, divided between British Columbia, Quebec and Ontario, in that order. Capacity now includes 834,550 bbl per day for crude refining in all Canada and 363,965 bbl per day cracking capacity (Table 1).

Though domestic crude runs to Canadian refineries were increased about 5 percent due to substitution of domestic crude from Ontario refineries in place of imported crude from Montreal refineries, total refining operations were practically the same as for 1957. This was due to the general business and industrial recession which showed modest improvement as the year came to a close. Total runs of crude in Canadian refineries amounted

The Author

H. G. Cochrane *became interested in oil development in the late thirties while making preliminary studies and estimates of oil pipelines to Lakehead and the Pacific Coast. He is a member of the Engineering Institute of Canada. After spending his early years on irrigation development in Alberta and Saskatchewan, he went east to build a number of large hydro-electric power plants in Quebec and Manitoba.*

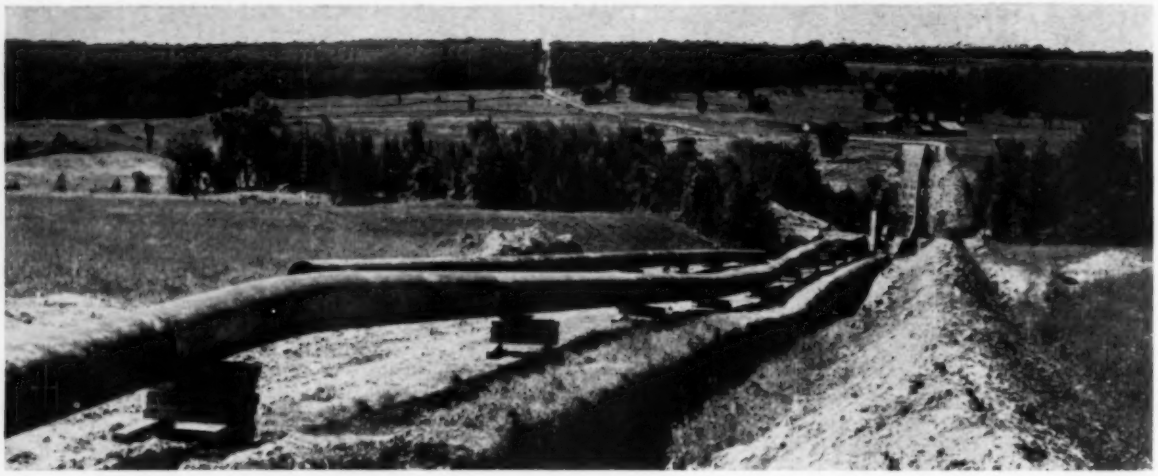
During World War II he conducted economic studies on scarce materials and services for the Canadian Government. He is presently with Power Corporation of Canada, Ltd. at Montreal. Since 1945 he has been writing annual reviews of Canadian oil and gas operations for this magazine.

TABLE 1. Oil Refining Capacity by Provinces.

	November 1958		November 1957	
	Crude Oil	Cracking	Crude Oil	Cracking
Nova Scotia	44,500	17,000	44,500	17,000
New Brunswick	300	—	300	—
Quebec	270,800	142,500	260,800	131,200
Ontario	230,000	97,600	207,500	90,600
Manitoba	35,000	7,375	35,000	7,375
Saskatchewan	70,000	26,600	71,000	26,600
Alberta	87,150	34,850	86,150	34,850
British Columbia	95,500	37,790	68,000	28,340
Northwest Territories	1,300	—	1,300	—
Total	834,550	363,715	774,550	335,965

TABLE 2. Western Canada 1957 and 1958 Drilling Completions.

	1957								1958								1958 FOOTAGE in Thousands	
	OIL		GAS		DRY		TOTAL		OIL		GAS		DRY		TOTAL			
	D	W	D	W	D	W	D	W	D	W	D	W	D	W	D	W	D	W
British Columbia	9	5	17	18	12	32	38	55	4	4	12	12	9	39	25	55	432	—
Alberta	746	79	41	74	66	395	853	548	807	101	91	117	56	351	954	569	6280	2368
Saskatchewan	760	43	7	6	81	248	848	297	431	33	13	11	81	149	525	193	2416	808
Manitoba	128	1	—	—	28	16	156	17	56	—	—	—	15	10	73	10	137	63
NWT	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	2
TOTAL	1634	128	65	98	187	691	1895	917	1300	138	116	140	161	550	1577	828	9266	3240



— Photo courtesy Trans-Canada Pipe Lines, Ltd.

Rock and muskeg does not always meet the pipeline construction crews in North Ontario. This lovely scene is near Trout Creek.

to 238.2 million bbl, compared with 239.6 million in 1957.

Refineries under contract for completion in 1959 and 1960 total 440,000 bbl per day capacity for crude, asphalt and aviation gasoline, and 50 million cu ft per day capacity for gas processing. Additions are divided by provinces as follows: Alberta 33,800 bbl per day; Quebec 24,000 bbl per day; Maritimes 38,000 bbl per day; and Alberta some 50 million cu ft per day gas processing capacity.

Eyes on Montreal Market

Throughout 1958 there was a continuing debate between "major" and "independent" crude producers respecting the merits or otherwise of opening up the Quebec market to western producers. The "independents" argue that Canada, voluntarily or with government support, should build a $350 million pipeline from Alberta to displace foreign oil now supplying Montreal refineries with some 250,000 bbl daily.

Studies have shown that, based on an average volume of 225,000 bbl per day, the cost of transportation in a new direct pipeline would be 73.9 cents per bbl, vs 69.1 cents per bbl through an expanded Interprovincial system. At lesser volumes the economic advantage is even greater.

With western fields capable of making the nation self-sufficient in petroleum in fact or in balance, there is strong pressure to speed progress in this direction by displacing imports of foreign oil at Montreal or by gaining a like amount of exports into Midwest and North-Pacific states. The latter choice would make better use of existing pipelines, would offer greater flexibility, and would avoid stirring up hard feelings south of the International Border and Venezuela.

Discovery Rate Discounted

A submission by British Petroleum (Canada) Ltd. to the Borden Energy Commission last fall pointed out that Canadian oil reserves were not increasing nearly fast enough to justify lavish extension of markets. The petroleum industry as a whole, it is predicted, would no doubt meet all demands up to 1980 at least, but distribution of production would tend to favor the Mideast, so that by 1980 Arab nations would produce nearly half the world's oil in contrast to their present 26 percent share.

This, the brief contended, puts Canadian markets and producability in their proper perspective. Discoveries so far, have not been such as to justify the assumption that Canada's oil has long term prospects beyond its natural market, which it defined as the area from Eastern Ontario to the West Coast, including the northwest and north central states.

For the long term, it claimed, to meet the possible demand in 1980 would require an oil-finding rate of 800 million bbl per year, though since Leduc the Canadian discovery rate had been only half this figure. Thus, the brief concluded, it was unlikely Canadian oil would in the long term be able to satisfy the whole of its natural market. It would be ill-advised to apply short-term relief, such as an extension to the Montreal market, to what is essentially a long-term problem that appears likely to be solved by physical limitations.

Expect Modest Improvement

Alberta producers started the new year with nominations totaling 383,715 bbl per day vs 365,860 in December, featuring a reduction for Transmountain and an increase for Interprovincial.

Some observers predict the upward production trend in crude production will be resumed in 1959, gaining possibly 5 percent over the 1958 daily average for an increase of some 25,000 bbl per day, or a total of some 171 to 173 million bbl for the year, regaining at least half of the volume lost last year. This assumes no increase in West Coast shipments for export, but also assumes U. S. import quotas will have no adverse affects on the current volume going to northern states.

Refining operations, they forecast, will improve moderately to some 250 million bbl, exploration will settle down at around 1000 crew-months unless there is a material change in the market outlook. Drilling activity will decline only about 10 percent below the 1958 level. With any increase in the oil market or further gas export the completion total could recover to 2500 wells and footage to 13 million ft.

Gas Operations Active

Canada's natural gas industry in 1958 experienced the most exciting year in its short history. Vast developments in all its phases were seen, from exploration and development drilling and completion of gas-processing plants by producers in British Columbia, Alberta, and Saskatchewan, to the arrival in late October of Alberta gas in the central provinces, replacing all imports, and extension of gas mains in many eastern municipalities.

Though not looked upon as an outstanding year for new discoveries, several important new finds were made. The most promising was the huge Berland River field in the foothills area of Alberta, 160 miles northwest of Edmonton, with a 600 ft Devonian D3 payzone. The initial open-flow potential of the discovery well at 400 million cu ft daily, was the highest rate ever

recorded in Western Canada. Another promising find of gas was at Panther River, 200 miles to the southeast of Berland, at a depth of 9000 ft.

Gas Output Up 40 Percent

Production of natural gas enjoyed a tremendous increase in 1958, to an estimated 400 billion cu ft compared with the 1957 total of 286 billion. Principal factor in the big increase was full-year operation of Westcoast Transmission's main line to the British Columbia interior and Vancouver and the export market to Pacific states.

Adding the volumes of gas already contracted for between Trans Canada and its 11 major utility customers between Regina and Montreal, totaling some 263 million cu ft per day, to Westcoast's current contracts of some 400 million, makes doubling 1958's total production within four or five years appear a distinct possibility, even assuming completion of no further export pipelines within that period. This means looping programs or complete new lines must be nearing completion by that time, to double capacity for the next period of expansion.

Pipeline Construction Big

The year 1958 was the third largest in Canadian pipelining history for natural gas transmission. The bulk of it occurred in Eastern Canada, where a total of some 1100 miles of main line was laid, most of it between Lakehead and Toronto. The rest was made up of some 1000 miles of laterals and gathering lines and about 1200 miles of local distribution systems.

Marketing Problems

But at least three major longer term problems are facing the natural gas industry. The first is the promotion and merchandising of the gas that is now able to flow through 2250 miles of the Trans Canada pipeline from Alberta. Total investment in Canada's gas industry has now reached very close to the billion dollar mark. At year-end there were more than 900,000 customers for domestic, commercial and industrial gas. If the present rate of growth continues distribution and consumption could soon be doubled. But it will take a tremendous concerted effort. An extensive advertising program is already underway, with utilities and appliance companies spearheading a campaign to sell gas.

A second problem is the impending competition from alternative fuels in Eastern Canada. This competition is dramatized by the current use by fuel oil dealers of placards proclaiming "Oil Heat is Safe," in an effort to discredit natural gas as a contender for the home heating market. The oil men should be able to hold their industrial customers and sign up new ones, but it is the domestic consumption where the real fight will occur.

— Photo courtesy Mobil Oil of Canada

Feeding drill pipe in as bit bores through rock on location north of Calgary in Alberta.

"Markets for natural gas may be affected severely by changes in the overall projection of economic development in the region, by the cost of service and by a complexity of factors involved in the use of underground storage, manufactured gas production, and possible natural gas production in Ontario." These were the major conclusions contained in a long and detailed study by the Stanford Research Institute and Economic Research Ltd., for presentation to the Borden Royal Commission last August.

"The price of natural gas for firm service in Eastern Canada is expected to be increased appreciably over rates presently in effect or pending," the study predicts. "On the other hand," it warns, "the prices of competitive industrial fuels have dropped 10 to 20 percent during 1958, due to competitive supply conditions, and this level of prices could last for some time." The price of heavy fuel oil would have to drop by more than 30 percent below 1957 prices," it was believed, "before alternative means of disposing of the heavy products would be profitable for refiners."

"Nevertheless, natural gas,' it states, "is expected to cause a reduction in the consumption of all other industrial fuels in the two provinces for several years. But only in Northern Ontario where coal is high-priced will gas have any significant impact on the use of coal, even for interruptible industrial use."

Export Policy Needed

Postponement of a decision as to national policy in relation to export of natural gas is the third and perhaps the most acute problem facing gas producers. This was emphasized in practically every submission presented last year to the Borden Energy Commission. Some of the capped wells have been idle for 20 years because there is no market within economic range. There is a more urgent need than ever before to secure some outlet for the greatly accelerating reserves of natural gas which cannot be marketed. Without even looking specifically for gas, the industry in the past decade has discovered most of the reserves of the more than 30 trillion ft presently remaining, or 21 trillion ft based on cautious conservation board standards.

The Borden Report

The Borden Energy Commission in its long-awaited first interim-report on natural gas, issued at the end of October, presented a series of major recommendations:

. . . that oil and gas pipeline rates be set by the Board of Transport Commissioners, based on fair return for shareholder's equity,

. . . that export of natural gas be permitted over the long term, but that immediate export by Trans Canada

at Emerson be disallowed until that company is assured greater supply. . . . that a National Energy Board be established to control export and movement across provincial boundaries, of all forms of energy.

"The excessive controls and regulation recommended threaten directly the well-being of the oil and gas industry and, by implication, Canadian business in general and the resource industries in particular," commented J. R. White, president of Imperial Oil. "The controls proposed could do little else than hamper the energy industries and restrict their development."

"Some of the practical defects of the report," he said, "were that it recommends gas export and then sets up a procedure that involves long delay in bringing it about. It makes practically impossible the securing of public participation in financing pipeline construction, and raises doubts about the sanctity of contracts as a basis of private financing. Such things as these undermine investor confidence."

Provincial Government reaction to the report was urgent, but restrained. The provinces were most concerned about ownership resources. But they can make a compelling case for retention of their control over these natural resources, returned to them by Ottawa 25 to 30 years ago. There is a collateral obligation the provinces, particularly Alberta, must respect, namely, to make surplus natural gas available. Since Alberta controls the gas without which no Federal control of pipelines can have any real effect, Alberta has tremendous power in the matter of export permits, since it could nullify many Borden recommendations by withholding.

The Borden report appeared to suggest a completely new set of rules for the oil and gas industries. But because recommendations were not spelled out, these industries are almost completely stalled and baffled until there is a clear definition of exactly how Ottawa will translate these recommendations into legislation. Their fears may be exaggerated, but nobody risks money where the rules may be changed while the game is in progress. It is vital that Parliament should clear up the whole matter as soon as possible.

Three Pipelines Projected

Two new pipeline projects are still awaiting approval to draw on the rapidly growing "wet gas" reserves of Southwestern Alberta for supplying the rich markets of California and the Pacific Northwest. One of these, sponsored by Westcoast Transmission, would provide a second Canadian link from southwest Alberta to feed through the Crows Nest Pass into the Pacific Northwest-El Paso system, already supplied by Westcoast from northern British Columbia fields.

Another project, the Alberta and Southern, proposes a $300 million pipeline linking up a huge gathering system from Peace River to the U. S. boundary, to be built by the Alberta Trunk Line to serve Pacific Gas and Electric territory in Central California. The two large distributors of gas in Alberta, Northwestern Utilities and Canadian Western Natural Gas, are partners in the venture. Its approval could introduce more competition for the vast foothill gas reserves so far uncommitted to Trans Canada, with better wellhead prices and a higher load-factor market for producers.

The Alberta Conservation Board in October advised these two pipeline organizations to re-submit their applications in January after reducing by 25 percent the volumes they proposed to export, implying export permits would then be approved. No permits are expected from the Board of Transport Commissioners nor from the FPC at Washington before late 1959.

Another multi-million dollar project is taking shape to market by-products separated from Alberta Natural Gas, to cost between $100 and $150 million. It would carry the products by pipeline in liquid form westward to Vancouver and eastward to the Canadian Lakehead ports or to Superior, Wisconsin. Backed by Pembina Pipeline, a new company, Foothills Products Pipeline Company, Ltd., has been formed to build and operate the pipeline facilities. Movement of some 100,000 to 150,000 bbl of by-products daily, or about a third of Alberta's current oil output is contemplated, with processing plants at the Pacific Coast and at the Great Lakes terminal.

Overseas Markets for Canadian Gas?

Canadian natural gas producers and pipeliners are watching an experiment taking place this winter when liquefied natural gas starts moving by tanker from a U. S. Gulf port to London, England. The delivered price is close to the same paid by a large Eastern Canadian gas utility to Trans Canada pipelines for Alberta gas. Success with the trial voyage would open up tremendous new markets for Canadian producers and foreign consumers.

Most European countries and Japan are potential customers. For Canada the most accessible energy market would probably be Japan where consumption could build up to nearly a trillion cubic feet in another 15 years, or more than four times Canada's gas consumption today. Gas from Northern Alberta and British Columbia fields could be piped to the coast and liquefied by refrigeration there.

Canada will have huge supplies of propane and butane as by-products, which are higher in Btu than natural gas. Problems relating to liquefying gas were easily solved but the difficult problem was how to store it to prevent leakage. Steel containers are used with 12-in. thick laminated balsa-wood liners which gives effective insulation.

Sulfur Rivals Gas

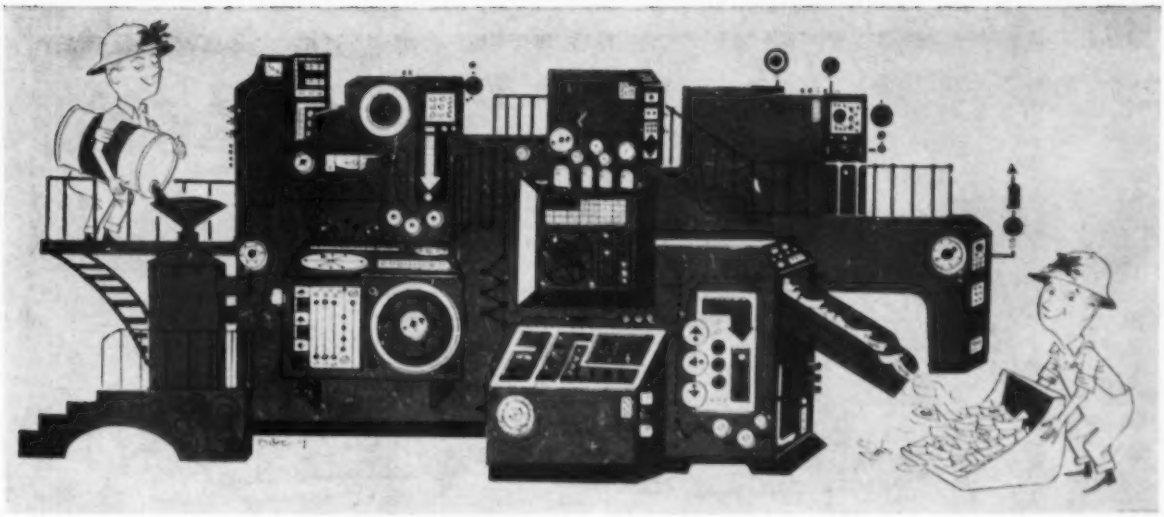
Canada's three most westerly provinces contain vast reserves of sulfur. Remaining reserves a year ago were estimated at some 30 million tons, while proved and probable reserves the same date were about 70 million tons. A Canadian Petroleum Association submission to the Borden Commission last year calculated a rough average potential recovery in four western provinces plus the Yukon and Northwest Territories at 260 million tons.

All the sulfur produced in Canada is elemental sulfur as a by-product of sour natural gas. In some fields the sulfur is worth as much as the dry gas itself after the sulfur is removed. There are today seven natural gas processing plants in western Canada, which can produce elemental sulfur; one in British Columbia, five are in Alberta and one in Saskatchewan. Daily capacity in these three provinces for sulfur is 300, 1200 and 8 tons respectively.

Today's producibility of sulfur is far beyond any visible market, and will become even more so over the next few years as export gas lines are built to carry the sour gas with high sulfur content from Alberta fields. Eventually there appears to be a possibility that Canadian sulfur markets will be able to absorb much greater production, though this does not help out the current state of oversupply.

Sulfur is just as important a resource as oil, gas, coal or uranium. It is so basic to the economy of an industrial nation that its standard of living may be measured by the amount of sulfur consumed. World consumption has more than doubled in two decades and will almost double again by 1970. Sulfur is the elemental ingredient in many petrochemical raw materials, with uses running from fertilizers to paper processing.

The challenge to present and potential producers of sulfur is to secure export pipeline outlets for natural gas, while meeting and beating competition during the period of excess supply. The solution does not lie in price cutting, but in creation of new uses for sulfur not yet found. This has been the successful method of attack in other branches of the petrochemical industry. ★ ★ ★



A network of electronic computers will soon be tackling problems all over this company's operations. They are lightning fast and incredibly accurate, but —

Are Computers Smarter Than Oil Men?

THE ELECTRONIC COMPUTER has become one of the handiest tools in the oil business. Almost overnight, the big "brain" has become almost as indispensable to oil men as the drill bit.

Socony Mobil installed its first computer in 1954, at the Research and Development Laboratory. The Mobil companies now have eight* in operation. Latest and largest is a $2,000,000 IBM 704, installed this spring in the company's new Electronic Computer Center in New York.

Installing the 704 was the result of a three-year study by an electronic computer committee headed by William V. Carver, Socony Mobil assistant comptroller.

The committee also has worked out a computer network which soon will be solving problems all over the Mobil world.

With the 704 as the hub, the network already is saving time and money for the company. Often, for example, one of the intermediate-size computers will chew on a problem awhile — then send it to New York for the big 704 to digest. It's more economical to let the intermediate-size computer work out partial answers, then let the 704 — which is 50 times as fast — come up with final solutions.

The network gets around the prohibitive expense of putting computers at many Mobil installations. Mobil people everywhere can get advice from the latest and best electronic computers on any problems worthy of such talent.

Plans are under way to handle many such quiz sessions by wire — using "transceivers" and other devices to transmit electric impulses long distances into punch cards on the other end. The first such transceiver link-up, spaning the 97 miles between Paulsboro and New York, was opened a few weeks ago.

How Smart Are They?

Some of the dramatic things that electronic "brains" can do are well-known — feats like playing chess, translating the Dead Sea scrolls and predicting election returns. But how can they help the oil man? What kind of problems can computers solve? How smart are they, anyway?

Dr. Julius Aronofsky, manager of the Electronic Computer Center, says:

"In all the talk about electronic 'brains,' we tend to compare the computer to the human brain. That's unrealistic. The computer reacts far faster than the human brain — our 704 can memorize a number in just 12 one-millionths of a second. But — let's face it — no computer can really think.

"When you get down to it, a computer can do only four things. It can add. It can subtract. It can multiply. And it can divide. Nothing more. But because it works at incredible speed, it can solve any problem that can be set down as a mathematical equation. And most problems can be, though many people don't realize it."

Take a problem like this: *How can*

*The lineup: Two IBM 650's at Magnolia Petroleum Company headquarters in Dallas; an IBM 650 at Magnolia's Beaumont refinery; a Datatron at the Field Research Laboratory near Dallas; a Datatron at the Research and Development Laboratory in Paulsboro, New Jersey; another Datatron at General Petroleum Corporation headquarters in Los Angeles; an IBM 650 and an IBM 704 at New York headquarters.

Editor's note: This article was published in the *Flying Red Horse* magazine of Socony Mobil Oil Company, Magnolia Petroleum and General Petroleum Company. Willard A. Colton is managing editor.

John L. Parris, *Manager Centrifugal Compressor Sales, The Cooper-Bessemer Corporation, explains...*

How you gain four ways when you specify Cooper-Bessemer Centrifugal Compressors

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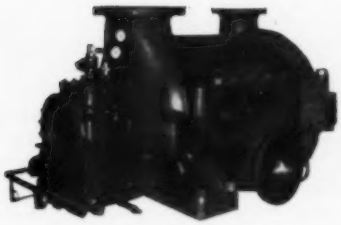

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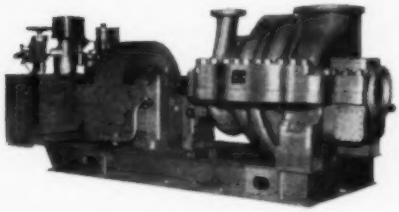

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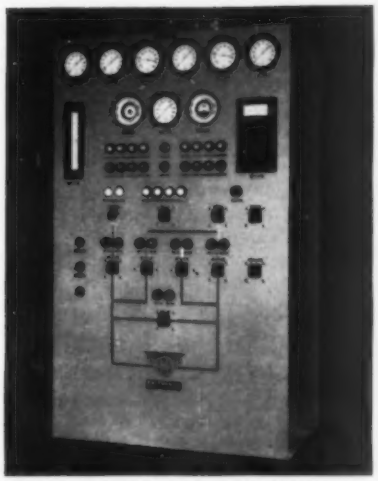

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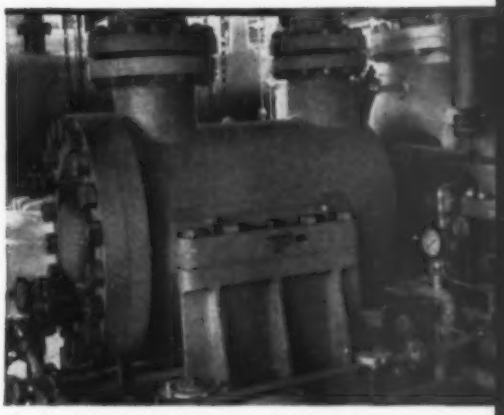

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a refinery give the marketers the highest quality products at the lowest possible cost? That's one that every Mobil refinery man would like to get answered. But it's tremendously complex. The quality of crude oil changes; the market demand changes; equipment can be run at different temperatures and pressures; you can feed catalyst through at various speeds — and so on.

At Paulsboro refinery it used to take two weeks to come up with recommendations whenever a change in refinery operation was needed.

Now the Paulsboro people can get their recommendations in as little as five minutes, using the transceiver circuit to quiz the 704 in New York.

What's more, the computer can provide Paulsboro management with many more alternatives than were possible before.

Floating Bum and Confusion

Many sets of punch cards coming into New York's Computer Center bear curious code names like "floating bum," "walk through the woods" and "confusion." A stack of "floating bum" cards may help bring in an important new oil well—or "confusion" may end a researcher's own confusion in a baffling scientific area.

Right now the 704 is working on an analysis of Mobil's complex product distribution patterns in the Midwest. Like many computer problems, this will not yield just one pat answer; rather, it will lead to many answers over the years to come. A similar study is advising Mobil Overseas Oil Company what transportation, refineries and distribution channels to use in Europe and West Africa. More and more, too, Mobil geologists use computers to analyze seismographic data.

The Center also turns out payrolls, sales statistics, dividend checks, Employees Savings records, and other financial transactions involving more than 10,000,000 entries each month.

"Any data-processing task that consumes a great deal of time — that burdens people with routine or complex computations — is a candidate for the computer," Dr. Aronofsky says.

Small wonder that Mr. Carver and his computer committee had nine months of projects lined up for the 704 on the day it was installed.

Decision By Machine

The computer is just one more machine in a company that already is highly mechanized — one more machine to help the company stay ahead of its competitors. Like other machines, it does certain tasks faster and better.

And because of its terrific speed, it can do some tasks that were not even possible before — and thus may open up new profit-making possibilities.

Some of these possibilities may be created by a technique called "linear programing."

"When we get the bugs out of linear programing," Dr. Aronofsky says, "computers won't just come up with alternatives. They will point unerringly to the best possible approach based on the facts they are given. For the first time, man won't have to wonder if perhaps there were a better way — if only he had time to figure it out. The computer, by compressing time, makes it practical to consider *all* the alternatives."

A computer, then, is a wondrous marshaller-of-facts. But *its facts can be based only on the information it is given.*

A mere man must then take the facts in hand—and weigh them against any number of forces that no computer can measure: The effect on employees, for example, or the effect on the public, or the current political situation, or the national security, or the wiles of the competition — just to name a few.

The computer can, in effect, make a recommendation. But only the oil man can make the decision. ★ ★ ★

"Businessmen Have Neglected National Affairs to Build World Industrial Supremacy" — Pyle

POLITICIANS AND LABOR leaders are rapidly assuming national leadership from those who produce the goods because of the American businessman's preoccupation with the task of building industrial supremacy to the neglect of his forceful participation in national affairs.

Howard C. Pyle, president of Monterey Oil Company, so described the plight of business and industry in his inaugural address as 1959 president of American Institute of Mining, Metallurgical and Petroleum Engineers at the 88th annual meeting of the Institute at the Sheraton-Palace Hotel in San Francisco February 18.

"American businessmen are fast learning that they have been losing public support," Pyle said. "While they have been building industrial might, which has added so much to our national wealth and well-being, they have relinquished leadership in our national affairs. They have been too busy to contemplate and adjust to the changes taking place in our social and economic environment.

"Through preoccupation with the job itself they have neglected the task of defending business against its opponents. Businessmen are now finding themselves maligned and their motives questioned. We must study and again understand the interdependence of business, political matters and the welfare and dignity of our people."

Pyle said it often seems unnatural for engineers to deviate from their professional calling. "In our studious, deductive approach to a job," he said, "we easily can be introverted and oblivious of outside activities. Today, each one of us should keep informed. We should know what our government is doing at all levels and we should be ready to take a stand on important issues.

"Here in California, within the last six months, I have seen companies unwilling to openly state their position on important public issues for fear of losing customers or would-be friends. We must do our own constructive thinking about the kind of society and the kind of government we want in this country, and then we must be heard from."

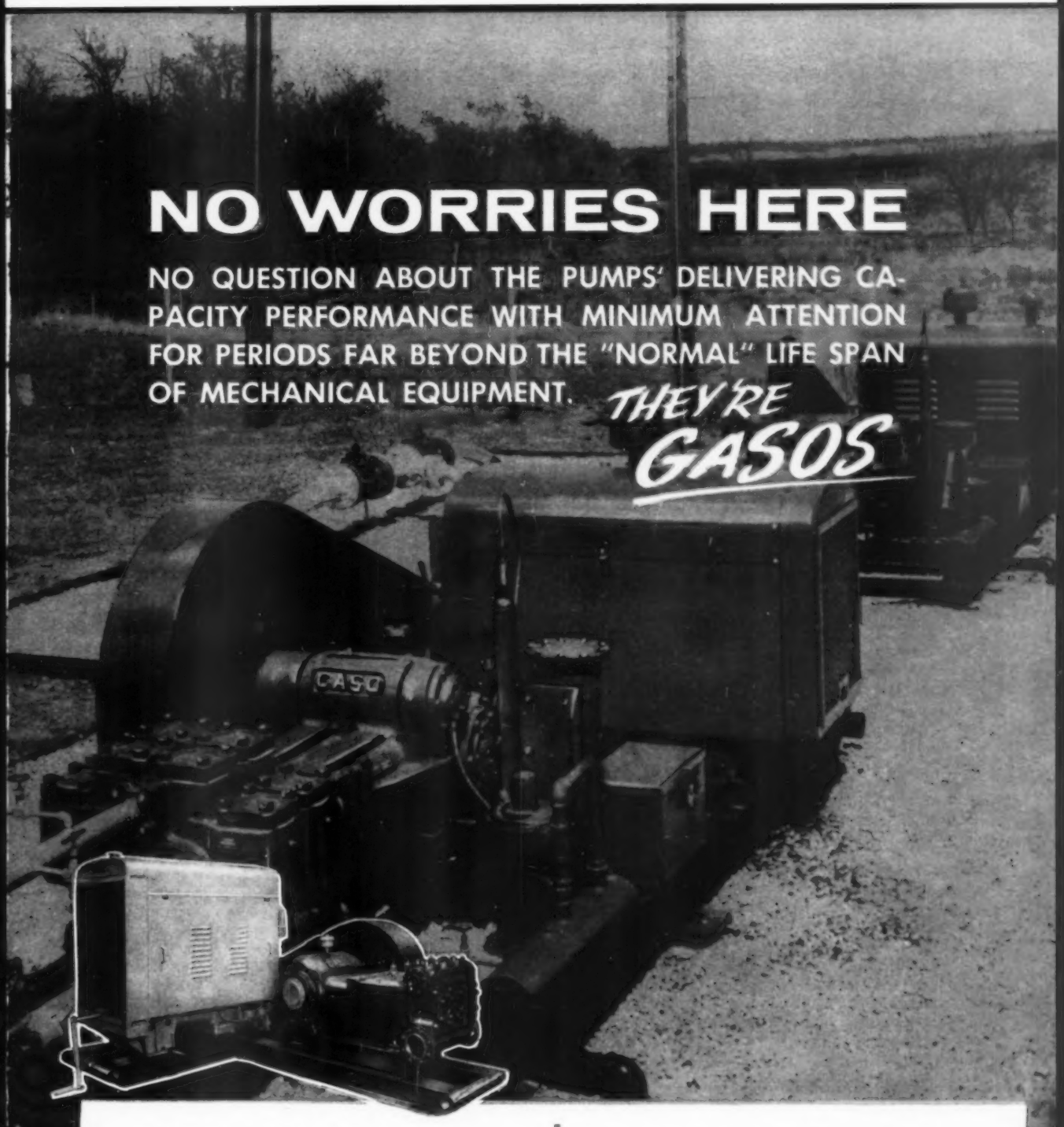
The nuclear and space age, Pyle stated, has destroyed forever the once comfortable security of our continent.

"We find ourselves interminably vulnerable," he said. "The problems of today are not only new, they are greater. America, with its increasing population, is experiencing a vast growth in industrial production. We no longer are self-sufficient in the many raw materials and important minerals we use. But from a world wide view, mineral resources are abundant.

"As engineers our horizons are broadened. It is not enough that we find, produce and process minerals. We must as individuals and as corporate groups participate in this growing and changing world.

"Foreign mineral production must play a part in the growth pattern of the producing countries themselves and we should help, not hinder, this growth. It is becoming more evident every day that no public nor private purpose can be sensibly planned with disregard for either domestic or foreign considerations.

"America has become great because of one basic philosophic idea, the idea that we can improve the lot of our people without interfering with their civil liberties. Needless to say, there are opposing ideas in the world today. Our engineers, at home and abroad, have more to do now than just their technical work. As professional men at home they share in the responsibility of preserving our heritage. When abroad the American engineer has even greater responsibilities. There, he is not only a professional man but a representative of a great and prosperous country and a way of life."



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WHY EMPLOYMENT ACT IS INFLATIONARY

Escalation wage contracts, sacrosanct markup rules and rigid cost accounting principles, and parity farm price supports are built-in inflationary bias we've allowed to creep in . . . These are greatest threat to maximum employment, says Dr. Edwin G. Nourse

ARE THE EFFORTS of the government to maintain and promote the volume of employment contributing to the problem of inflation? More broadly, is there a conflict between the objective of "full" or "maximum" employment and that of sound money?

These questions have troubled observers ever since it was first proposed that the government accept responsibility for the volume of employment, and 12 years of experience under the Employment Act have certainly not tended to allay the concern.

The problem is now a subject of official inquiry. Earlier this year the Joint Economic Committee published a compendium of papers prepared at the committee's request by 47 economists from universities and research organizations.

Inflation Threatens

Why this growing concern over the possible contradiction between the long-recognized responsibility of government to maintain the value of money and the more recently assumed obligation to promote "full" or "maximum" employment? Partly, at least, because the misgivings that arise from common-sense considerations are being confirmed by experience.

Production, and hence employment, depends upon the demands of buyers, and in an economy of individual choice, government cannot directly regulate the behavior of the millions of consumers and investors who buy the products of industry. Government can affect demand to a major extent only by manipulating the money supply; that is, by inflating or deflating the currency.

In practice, deflation on a significant scale proves virtually impossible. Over a period of time, therefore, the net effect of governmental manipulation of the money supply is almost certain to be on the inflationary side.

Editor's note: Condensed from The Guaranty Survey, published monthly by Guaranty Trust Company of New York.

The political pressure for a larger money supply is strongly reinforced, if not actually initiated, by the constant demands of powerful labor organizations for wage increases out of all proportion to the rise in the productivity of industry. To meet these demands, employers are forced to raise the prices of their products. And the government and central banking authorities can refuse to make enough money available to support the higher prices only at the risk of restricting total demand, bringing on unemployment, and thus running counter to the "full-employment" program.

The upward pressure on prices is further strengthened by other governmental policies, such as price supports and stockpiling operations. All such activities form part of the economic climate in which "full-employment" policy is pursued, and help to explain the persistent inflationary problems.

"Full" vs "Maximum"

Effects of a policy or program obviously depend to a large extent upon the rigor with which it is pursued. Ever since the Employment Act was passed, there has been controversy over the nature of the responsibility which it places upon the government. Some have contended that the law is an unqualified mandate to all federal departments and agencies to see to it that everyone "able, willing, and seeking to work" is provided with a job, and to do this at any and all costs.*

Others have argued that "full" or "maximum" employment is a goal or target, not a fixed obligation, and is to be pursued with due regard for the many other duties, obligations and responsibilities which the government must fulfill, one of these being to maintain a sound and stable currency.

The more moderate interpretation has now received strong support from official quarters. At the opening of the joint committee's hearings, Representative Wright Patman, chairman of the committee, offered "for the record" a study prepared by the committee staff in April 1955, and never before made public, entitled "The Significance of the Words 'Maximum Employment' as Used in the Employment Act of 1946."

*This will be stand taken by many recent victorious Congressmen who used "full employment" on their vote-getting program.

Ideal or Formula?

Significant is the finding by the staff that "it seems clear from the legislative record that both 'maximum employment' and the earlier expression 'full employment' were thought of as goals rather than as guaranties."

Mr. Patman gave further support to the "moderates" by pointing out that "from the beginning . . . the Joint Economic Committee has had to be concerned with the problems of promoting the stability of the general price level and the need for combating inflation."

A key witness at the recent hearings was Dr. Edwin G. Nourse, former chairman of the Council of Economic Advisers, the Federal agency created by the Employment Act.

Dr. Nourse said: "If . . . ideally full employment would be such as promotes continuous maximization of production and real purchasing power for the people, it cannot be attained in the face of any disturbance in the monetary mechanism that would be harmful to business activity and general spending and saving for capital formation."

When Policy Is Inflationary

In specific answer to the question, "Under what conditions would stabilization of prices be inconsistent with the attainment of Employment Act objectives?" Dr. Nourse suggested the following: "When the use of government fiscal and monetary restraints was so drastic as to hold the price level steady in the face of private market

institutions and practices in which price maintenance laws, nationwide escalation wage contracts, sacrosanct markup rules and rigid cost-accounting principles, and 'parity' farm price supports are widespread and well entrenched.

"There is no reason in economic logic, or, if you please, price mechanics, why our economy should not combine vigorous growth with such stability of the price level as would be reassuring to the businessman and the investor and equitable to the various groups in the society. But it would require the flexibilities of a truly competitive business structure and practices. . . . The greatest threat to the accomplishment of the objectives of the Employment Act is to be found in the rigidities or the built-in inflationary bias that we have allowed to creep in."

Those who have been pleading for a realistic interpretation and administration of the Employment Act could hardly ask for more explicit or more authoritative confirmation of these based principles, which they have consistently stressed:

1. That practical reconciliation of the objective of "full" or "maximum" employment with that of stable money is a still unsolved problem.
2. That the Employment Act is not intended to guarantee any fixed level of employment and does not require or authorize the government to subordinate other objectives to that of "full" or "maximum" employment.
3. That high levels of production and employment depend primarily upon natural market adjustments and cannot be permanently maintained by fiscal or monetary manipulations.
4. That progressive currency depreciation tends to defeat rather than promote the long-term objectives of the Employment Act.
5. That booms beget recessions, and hence recessions can be avoided only to the extent that booms are avoided.
6. That the practical danger in the Employment Act arises from
   (a) the demand for perpetual boom by fiscal and monetary manipulation and
   (b) the "built-in" market rigidities and inflationary pressures under which the act has been and is being administered.

Recognition of these cardinal points in such authoritative quarters encourages the hope that the inflationary potential of the "full-employment commitment" may be minimized if not completely eliminated. ★ ★ ★

Compromise on Oil Imports Proposed

Areas of agreement found between independent producers and international companies

ARGUMENTS for a "compromise solution" of the oil imports problem conclude an academic study of both sides of the question by Fordham University in connection with its Industrial Economics program.

As the sixth in a series of studies in industrial economics, under the direction of William T. Hogan, S. J., the analysis has been published by Fordham University Press in a 100-page volume, "The Oil Import Problem."

For the first time, the study presents an objective history of both sides of the oil imports problem. It reports on government and industry efforts to reach an equitable solution, examines the divergent views concerning the volume of imports which should be allowed and concludes that a "flexible and easily amended" compromise formula must be developed.

The author, Sebastian Raciti of Fordham, reports important areas of agreement between the primarily domestic producers and the major importing companies. The basis for a future solution lies in these areas of agreement, he says.

Both groups agree that the domestic petroleum industry must be kept sound and that an excessive level of oil imports can adversely affect the nation's defense, Raciti points out. In outlining the position of each group, he comments that each believes its own policies in regard to imports are in the best interest of national security.

Raciti reports that "most majors also feel that imports should be kept at a reasonable level, but they also contend that present import levels are not excessive. According to them, the present condition of oversupply is due primarily to unnecessary increased activity by the domestic industry in the face of declining demand."

The majors, Raciti reports, "point out that since they also rank among the largest domestic producers, they are equally dependent upon their domestic operations and are therefore unwilling to pursue policies that would weaken their own companies. However, some maintain that oil imports have not been excessive."

The case for the independents, as presented in the book, explains that although 22 larger companies refined 86 percent of the total crude in 1956, they produced only one-half of their crude requirements in the United States. The remainder of their needs was supplied either by purchase from the independents or through imports.

Raciti explains that oil and gas account for two-thirds of all the energy consumed in this country, making it clear that "a direct relationship exists between our national security and the maintenance of an adequate supply of readily available petroleum." He refers to government studies during the last few years which stress the need for a strong domestic industry.

Explaining how the domestic industry would deteriorate in the face of excessive imports, Raciti writes:

"If the domestic producer is unable to sell his crude, his income will decline and he will be discouraged in the development of new sources of oil. This is so for two reasons: (1) Reduced income may prevent the independent from setting aside the sums of money needed for domestic development; and (2) he might be unwilling to spend his reduced income for oil that he cannot market."

Stressing the need for a compromise solution, Raciti says the importing companies must share the responsibility of cutting back their imports whenever the domestic industry is forced to reduce its production in a period of oversupply. They must realize, he says, that "if foreign oil is to share the benefits of an expanding future domestic market, they must also share the losses involved whenever a period of oversupply exists."

More studies and compromises must be made to determine what would be a fair share of the home market to grant to the oil importers, Raciti says. Whatever percentage is decided upon, it must be respected and maintained by the oil importing companies, he points out.

New legislation would not be necessary to enforce an equitable, flexible oil imports program, Raciti concludes, "if the independents and the majors accepted their responsibility and agreed to abide by the decisions of the regulating agency."

"Whatever plan is decided upon," he says, "it must provide that:

1. The nation be assured of a reasonable oil supply;

2. The means for an adequate and uninterrupted transportation of distant supplies be maintained;

3. The domestic industry be kept sound and healthy." ★ ★ ★

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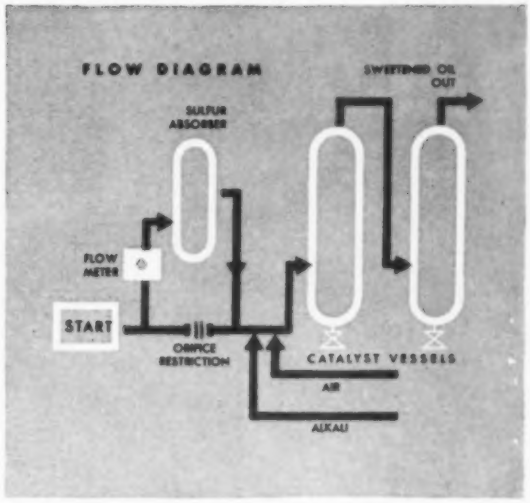

IF SWEETENING IS ONE OF YOUR REFINERY PROBLEMS...

these facts about PETRECO BENDER Catalytic Sweetening† may show you the answer:*

LOW OPERATING COSTS: The average treating costs of Petreco Bender treating units are about 0.5 cents per barrel. Copper chloride or doctor treating costs, exclusive of amortization, generally exceed 1.0 cents per barrel. *The value of the volume loss in doctor treating alone often exceeds the total operation and amortization costs of Petreco Bender catalytic sweetening.*

SWEET NON-CORROSIVE PRODUCT: As compared to doctor treating, less sulfur is used, resulting in the delivery of a consistently non-corrosive product. *The use of less sulfur also lessens octane loss.*

ELIMINATES AIR AND WATER POLLUTION: Processing is in a closed system, eliminating air pollution and the attendant safety hazards. This eliminates open batch type agitators, thereby assisting in safety programs. *There is no "black strap" carry-over or carry-under to contaminate waste disposal systems.*

The product from the Petreco Bender unit is low in trace metal ions. Where a water wash is required to meet local product specifications, emulsion problems are not encountered due to the cleanliness of the Bender treated oil.

The only spent alkali withdrawn from the Bender unit each day is the small amount not consumed in the process.

HIGH YIELD: There is no volume loss in the system other than sampling and spillage. The volume loss in other sweetening processes is the greatest expense factor.

CONTINUOUS REGENERATION NOT NECESSARY: The catalyst retains its activity for long periods of time. This is made possible by the continuous addition of small quantities of air and alkali. Catalyst life without reactivation is usually two years or more. *Two Petreco Bender plants have been operating for over three years without any reactivation of the original catalyst.*

LOW INSTALLATION COST: *Unit cost for new equipment is comparatively low, ranging from $15 to $30 per barrel of daily throughput capacity.* If existing vessels are available and appropriate for conversion, this cost can be substantially reduced. Very often the charge may be taken directly from a distillation unit with existing pumps, exchangers and instrumentation, reducing the installation cost further.

SMALL TREATING AREA REQUIRED: Where ground areas are congested, the area occupied by any treating unit is of great importance. The plot dimensions for a 5,000 bpd Petreco Bender unit, for example, would be approximately 20′ x 35′.

† *For middle range distillate streams such as kerosine, stove oil, light gas oil, No. 2 fuel oil, coker naphtha and catalytic gasoline.*

*PETRECO *is a registered trademark of Petrolite Corporation.*

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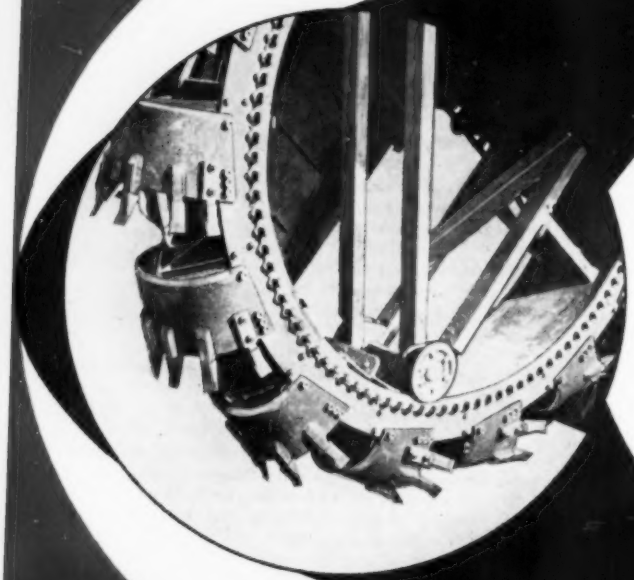

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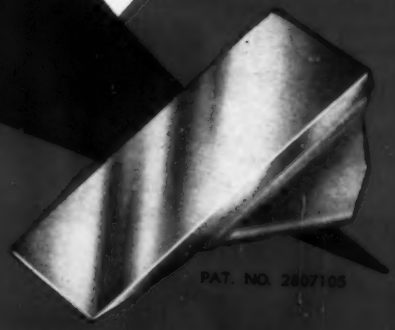

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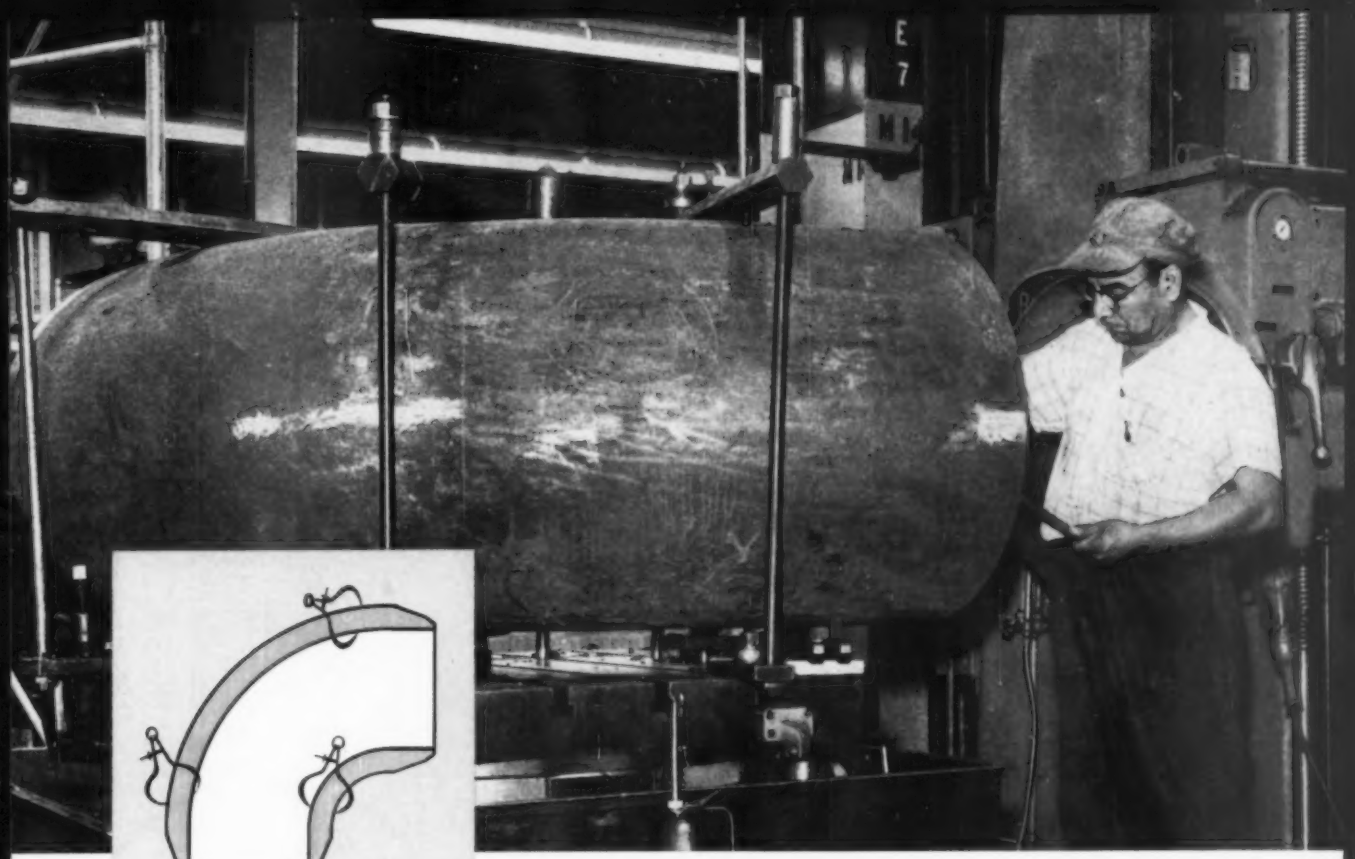

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The Hortonclad bulletin will show you why industry leaders are turning to *Hortonclad* structures... wherever corrosive material is stored or processed. Write your nearest CB&I office for a copy.

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The Baton Rouge Powerformer has an estimated capacity of 26,900 barrels per day and produces powerformates for high octane motor gasoline blending.

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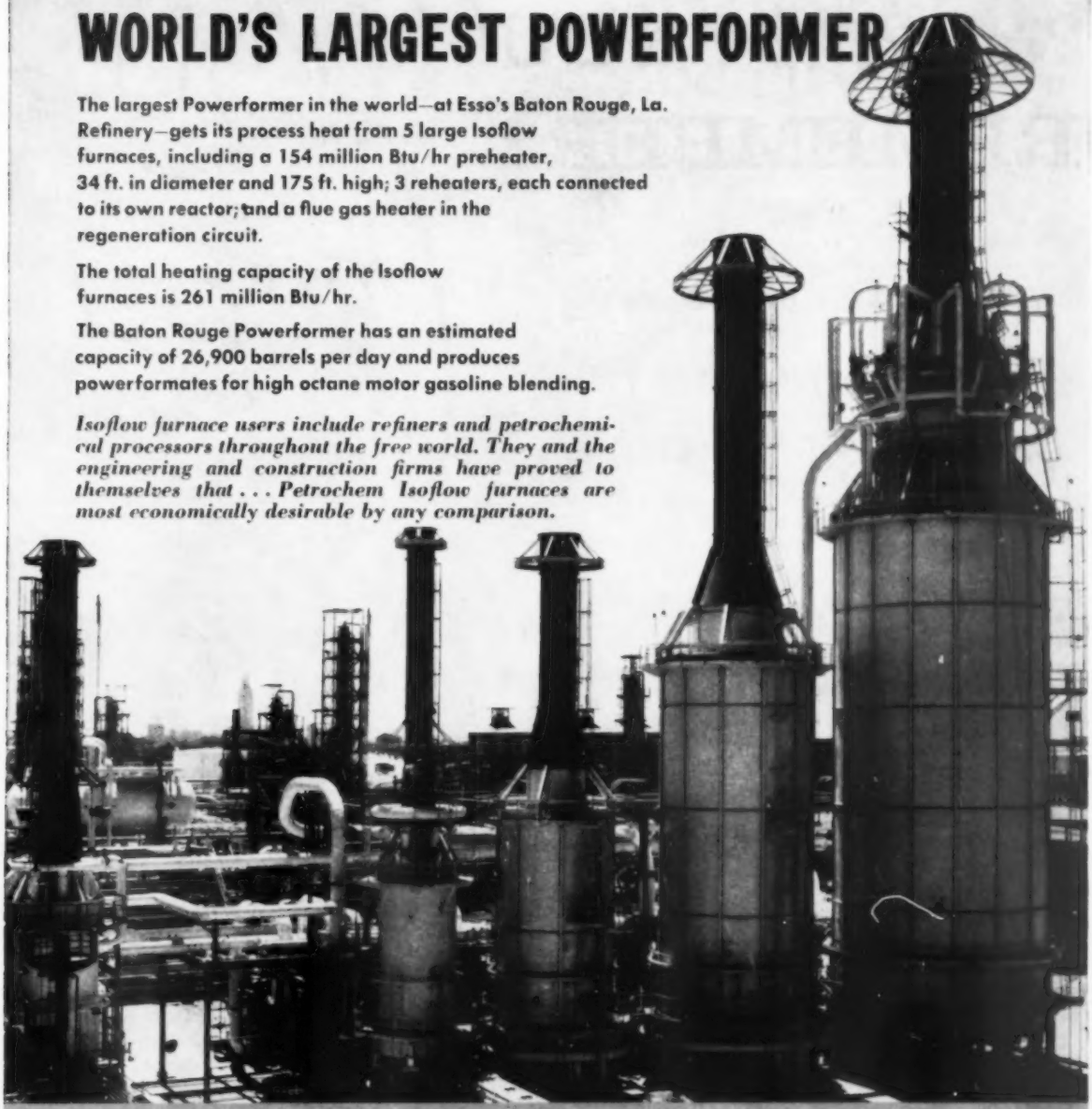

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???????? DO ???????? YOU REMEMBER?

If you don't, there are memory aids as old as Mnemosyne to help you

This fellow is the forgetful type. But, he's trying to improve his memory. The string helps if he can only remember what it is to remind him of.

OUR AGING CITIZENS ofter complain about poor memory. One elderly man put the problem this way. "As I grow older my memory gets worse in three ways. I tend to forget names, I forget faces . . . and let me see now — what is that third thing?"

Most of us feel that we started out with bad memories. Names, faces, dates — all slip back into a morass of unremembered and unrelated facts. But psychologists say it isn't so; they say we started with the ability to remember, but it was just easier not to take the trouble. Memory aid authority Dr. Bruno Furst says "memory is like a muscle; the more you exercise it, the better it works."

There's no denying the brain has to work to store up specific memories. Man has always tried to devise ways of making that brainwork easier. Probably the first cave woman tied a plait of grass around her husband's finger to remind him of something.

Memory Aids to Love

Memory aids dating from early times include objects to keep a loved one in mind. It could be anything from a scarf to a bit of curly lock. The Romans were more specific. Officers off to a war would present wife or sweetheart with a ring or pendant carved with the Latin word for "remember."

Modern reminder services are the latest device to jog failing memories. They can help you — for a fee — to remember anniversaries, birthdays, or things like due dates for income tax payments. And, in television, a whole new industry has grown up in the promoting field, where a machine controlled by an off-camera operator reels off the script for many leading performers.

Mechanical Aids to Memory

But these mechanical devices are often too bulky to carry around or too expensive to employ every time you need to remember something. A string around your finger isn't bulky, but it's just possible you might forget why it's there.

Memory experts say: Use that string if you must, but tie it in with a mental image of some sort. Suppose you tie it around your finger to remind you to buy a dozen eggs. Here's where the artificial memory aid — stored in the brain itself — can help. You are advised to think of the string as hanging over your head holding the half open carton of eggs. If you pull the string, an egg will drop on you. It's a pretty good bet you'll think of eggs the next time you see a piece of string. Farfetched? Of course, but that's one of the first rules in trying to remember. Make your mental images unique . . . the more extravagant, the easier to remember.

Shoppers generally have to remember long lists. That's where mnemonics come in. Mnemonics, or mnemotechny, or artificial systems of memory, have been in use at least since the early Greek civilization — centuries ago. In fact, the word "mnemonic" is derived from Mnemosyne, goddess of memory who probably had to have a pretty good memory to remember the names of her nine famous daughters — Calliope, Clio, Erato, Euterpe, Melpomene,

Reprinted from August 1958 issue of *Aramco World*, published by Arabian American Oil Company; Thomas J. Gartland, editor.

Tough, colorful, lasting beauty!

Take those pumps and rigs in the oil fields—or those tanks and pipelines in the refineries! Each needs the tough, colorful, lasting beauty that Rust-Oleum provides. If the surface is rusty, Rust-Oleum 769 Damp-Proof Red Primer can be applied *right over the sound rusted surface* after removing rust scale and loose rust. Special Rust-Oleum Oil Field Finishes match the original equipment colors on pumps and rigs – while other long-lasting Rust-Oleum coatings protect costly tanks and pipe lines.

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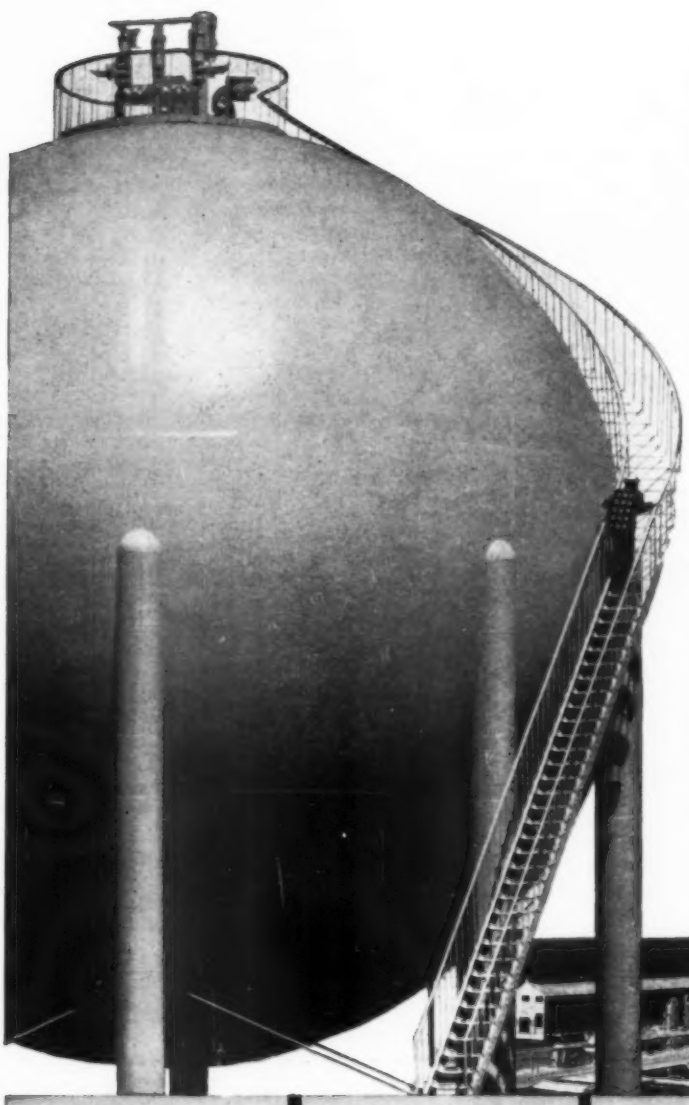

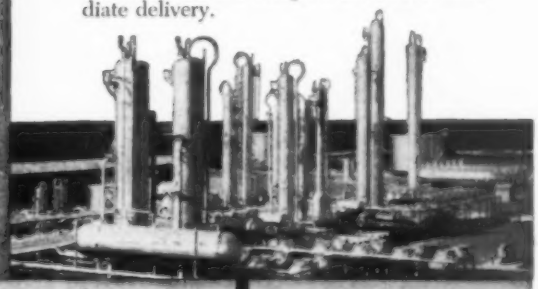

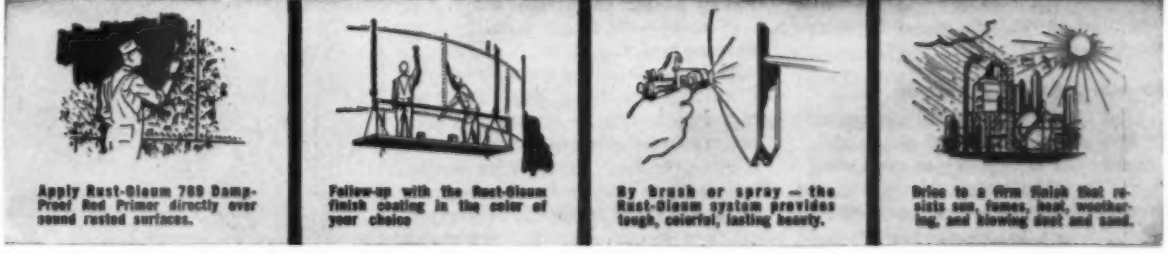

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Memory By Place

The first recorded memory aid seems to have been a system set up by a Greek poet of the late sixth century B.C. named Simonides. The user of this system always remembers, in a certain order, the parts of a room entirely familiar to him. The left side of the entrance door might be number one, the top of the door number two, the right side number three, and so on. To apply this to a list, the user makes a mental picture of the room, assigns items on the list to sections of the room in order. For instance, five pounds of sugar will be placed to the left of the entrance door or in number one position, etc. In this way, he can recall them anytime by a quick mental look at where they are placed.

Memory was the subject of one of the earliest books printed on movable type. Jacobus Publicius, a Florentine, published "Ars Memorativa" in 1470. It contained rude woodcuts that illustrated Simonides' system. It went a step further and offered symbols for the alphabet so forming another way of remembering. Twenty years later in Padua, Professor Pietro Ravenna published a system which used "the most beautiful maidens his mind could conceive" as keys for the items on his list. He figured such examples of beauty could not fail to excite the memory of his scholars in those days before coeds.

In 1523, Laurenz Fries gave advice in a work titled "How Memory can be Wonderfully Strengthened": "Partake of roast fowls, small birds or young hares for dinner, then apples or nuts for dessert. You may enjoy good red wine, otherwise be sober and moderate." In 1661 a tract by one John Willis suggested drowning "all unnecessary thoughts in oblivion."

Memory by First Letter

One of the commonest mnemonics to help recall a series of names is to combine the first letter of each word so that together they create a new word. Students faced with learning reams of information often employ this device. This is how it works: If, for example, you want to memorize the names of the cabinet posts in the United States Government, bear in mind the fictitious saint — St. Jadchip. Each letter represents one of the cabinets — State, Treasury, Justice, Agriculture, Defense, Commerce, Health, Interior and Post. If Mnemosyne had trouble calling her daughters by name, she could have taken a lesson from classics scholars who commit the Muses' names to memory by forming the word Tec-Pum-Tec (which sounds like the title of an Aztec deity.) See if you can cite the nine names from this mnemonic. The more strikingly exotic the invented word, the greater are your chances of not forgetting it.

Memory by Mental Picture

If you ask some memory experts to repeat a list, they'll make a mental picture of the objects mentioned. Each picture will be associated with a key symbol from his system, so that he can remember any item, in or out of order, backward and forward.

Here are some hints for remembering names and faces. Once again the trick is mainly taking the trouble to remember. When introduced to someone, an effort has to be made to hear the name, or have it repeated. Our experts advise that this request will flatter rather than offend. Spell the name out. If the name's odd, mention it. If it's like someone else's name, make a note of that fact. Repeat the name during conversation, then use it in saying goodbye — and the chances of remembering it are much better.

Memory by Association

As for faces — most of the experts agree that the name of a person should in some way be tied to some facial characteristic. Here's where ingenuity comes in again; the more ridiculous the association, the easier it will be to remember. (Does the Mr. Brower you have just met have prominent *eyebrows?* Can you picture Mr. Cook *cooking* a meal? Does Mr. Young who has been introduced to you have a *young* face? Imagine Mr. Chase on a fox hunt; Mr. Knight, in a suit of armor; Mr. King, enthroned.) Everyone in the world has some distinguishing marks such as an odd hairline or the lack of one; perhaps the shape of a head or the walking gait is outstanding for some reason.

And, say the better memory people, if you slip once in a while, don't be discouraged. One of the top moneymakers in television quiz-games, a woman who kept the isolation booths busy in more than one return engagement, was asked to appear on another television show to explain how she did it. She said she'd be glad to — and full arrangements were made. On the date set, her agent showed up early at the television studio, with assurances she'd be there at any moment. As program time approached, the assurances became less frequent — and finally he rushed to the phone.

He came back crestfallen. The lady with the wonderful memory — who had won thousands of dollars by remembering fact after fact — had forgotten all about her scheduled appearance. ★ ★ ★

USSR Hits Highest Oil Production

THE SOVIET petroleum industry is still plagued by shortages and inefficiency despite substantial increases in oil production during 1958.

USSR oil output climbed to a record 2,270,000 bbl a day in 1958 compared with 1,966,000 bbl a day in 1957, a 14 percent increase. But Russian officials complain that still greater production should have been possible, Izvestia reports. In 1957 increase over 1956 was announced as 17 percent.

In Bashkiria, part of the prolific "Second Baku" area between the Ural Mountains and Volga River, 109 wells completed during the past six years are not yet producing because they have not been connected to pipelines. The official government newspaper Izvestia says these inactive wells represent an investment of 140 million rubles ($35 million at the official rate of exchange) and potential output of 7000 bbl a day.

In Perm Province, to the north of Bashkiria, the chief of the Oil Industry Administration charged that newly discovered oil fields are not being developed because of "a shortage of drilling rigs, tractors, heavy-duty trucks and equipment for expediting pipeline construction." He reported that construction of the Yarino-Perm pipeline, slated to begin in 1957, still has not started because promised money and pipe failed to arrive.

A comprehensive study of Russian economic progress was recently released by Lionel D. Edie and Company, an investment and consulting firm. It points out that oil output is increasing rapidly. Here is the record:

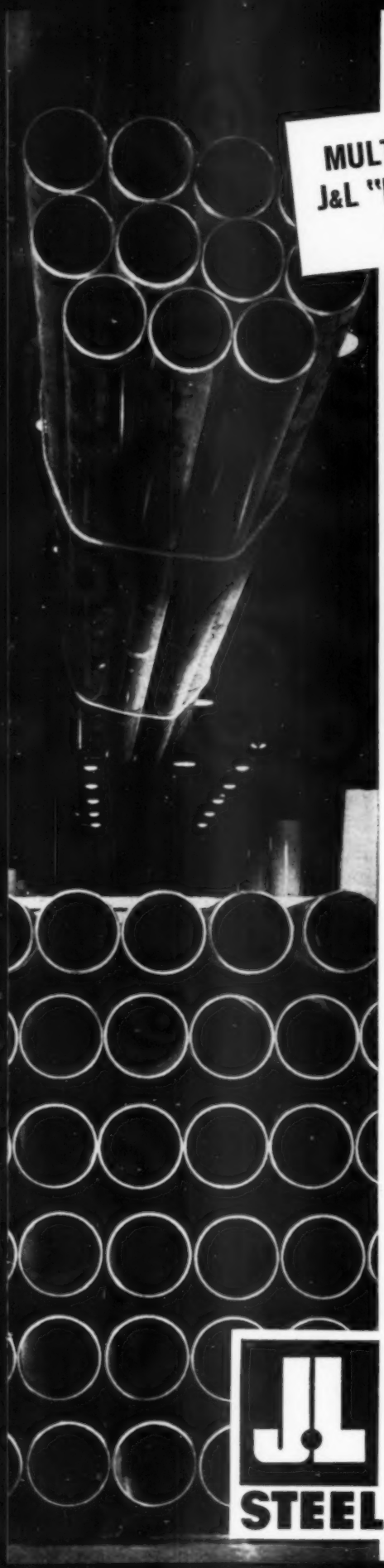
Crude Petroleum Production
Thousands of Metric Tons

	Soviet Union	United States
1913	9.2	33.5
1928	11.6	121.9
1932	21.4	106.1
1937	28.5	172.9
1940	31.1	182.9
1950	37.9	266.7
1954	59.6	312.8
1956	83.8	353.7

Source: Soviet Union: 1913-1954, *Statistical Handbook of the U.S.S.R.*, p. 36. *1956* — Harry Schwarz: *The Soviet Economy 1956-1958*, p. 14.
United States: 1913-1932 *Historical Statistics of the United States* 1789-1945, p. 146.
1937-1956: *1957 Statistical Yearbook of the United Nations*, p. 152.

According to last year's review[1] the Soviet planned a $1 billion expenditure on expansion in 1958. This is low in comparison to U. S. private investment but is at least a third higher than 1957 capital budget for the USSR industry.

[1]11th Annual World Round Up, Ernestine Adams, *The Petroleum Engineer*, July 1958.



MULTIPLE-TESTED J&L "ELECTRICWELD" LINE PIPE

J&L's 12¾-inch Electricweld line pipe was used in 22 miles of this Cherokee Pipe Line Company line.

"J&L Electricweld pipe bends readily to contours, is easy to weld"

. . . reports Pipe Line Service Company

Twenty-two miles of J&L's 12¾-inch O.D. Electricweld line pipe were installed by the Pipe Line Service Co., Seminole, Okla., in this line for the Cherokee Pipe Line Co.

"Our pipe must be uniformly round, bend readily to correct contour, and weld easily," says this pipeline contractor. "J&L pipe meets our specifications. It enabled us to avoid delays on this job over hilly terrain."

Electricweld line pipe is produced by Jones & Laughlin, an integrated steel company, under most rigid quality controls. Weld area of the steel is blasted with steel grit under 100 psi in a "Vacu-Blast" unit to clean the surface for perfect contact with the welding electrode.

During the electric resistance-welding process, electronic controls maintain exact welding heat at all speeds. After welding and trimming, pipe passes through an induction annealing unit to assure uniform grain structure in the weld area.

Every length of pipe is thoroughly checked through visual examinations, hydrostatic tests, flattening tests and magnaflux inspections. All Electricweld pipe is manufactured and tested in strict compliance with appropriate A.P.I. and A.S.T.M. specifications.

Electricweld pipe is available from 6⅝ inches through 12¾ inches and in lengths to 60 feet. Get the facts on this superior quality line pipe from your distributor, or write to Jones & Laughlin Steel Corporation, 3 Gateway Center, Pittsburgh 30, Pa.

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J&L STEEL

ENGINEERS: Professionals or Labor?

APPROXIMATELY 10 PERCENT OF TODAY'S ENGINEERS ARE UNIONIZED. COLLECTIVE BARGAINING EFFORTS OF THE MEDIOCRE FEW ARE INJURING THE OTHER 90 PERCENT IN ENDEAVOR TO OBTAIN RECOGNITION AS PROFESSIONALS

Sid Newburger

THE ENGINEERING profession has come a long way in the last 50 years, from a small group of technical minded mechanics to the highly specialized college trained engineer of today. One might think the engineer of today is professional in every respect. But is he really? Many punch time clocks, are hired and fired in groups. Is this professional living?

Here we arrive at the stated object of engineering unions: To further the professional status of the engineer. Whether or not they accomplish their goal is a matter of opinion. In the opinion of the ESA (independent Engineers and Scientists of America), an engineering union, the only way for the engineer to gain his "rightful place in American industry" is through unionization.

Collective bargaining has paid off to some extent in attaining the professional goals of the engineers. Contracts have been procured in which the employer has agreed to pay the engineer's society dues, set up night study programs leading to higher degrees at the expense of the employer, and give engineers time off with pay to attend professional meetings, conventions, and conferences.

Contrasting the views of the ESA, the various engineering societies believe that professionalism through unionization can never be. They give as evidence the fact that in the first four years of ESA's existence there were five strikes. Certainly this was of no help in reaching professional status regardless of the gains resulting, for along with them were the pickets, mobs, hard-feelings, and violence that may accompany a strike. Progress of these strikes was covered by the various communication services, and the nation saw, read, and heard about an organization of "professional" engineers that was striking to get what it wanted. Strikes may be quite fair and reasonable for the production worker, but are they for the engineer?

Immediate short term gains may be accomplished through unionization, but these minor gains are hardly leading the engineer down the paths of professionalism. Getting industry and the nation to accept the engineer as a professional will take a long time. You can't shove engineering as a true profession down the time-hardened throats of management any more than you can make them accept an automobile mechanic as a professional by pointing a shotgun at their heads. It is analagous that the medical profession had to strive for hundreds of years to be accepted as more than just alchemists or quacks.

In the eyes of our national statutes the engineer is recognized as a professional. The Taft-Hartley Act, passed in 1947, strengthened the position of the professional employee by defining what a professional is and it gave any group of professional employees the right to join or not join a bargaining unit. This gave the engineer freedom of choice for in some plants union membership was a requirement for all employees.

At the present time, engineers have banded together in two types of bargaining organizations. One is the professional engineering union which restricts its membership to professionals. There are 40,000 engineers falling into this category with 30,000 of them belonging to the independent Engineers and Scientists of America (ESA). The remaining 10,000 belong to various regional and local unions also professional in nature.

Other engineering unions include technicians, draftsmen, and semi-professional classifications. Oldest of these is American Federation of Technical Engineers (AFTE), AFL-CIO. Formed in 1918, the AFTE restricts its membership to technical personnel. Due to its backing by the AFL-CIO and a concentrated program of campaigning, the AFTE has attracted a large number of new members in recent years. It has a membership of over 15,000 at the present, and it is the fastest growing of all engineering bargaining organizations.

In addition some engineers belong to production workers unions like the United Automobile Workers, United Steelworkers, and the International Brotherhood of Electrical Workers.

At present approximately 10 percent of the nation's 500,000 engineers are unionized. The trend is on the increase right now, but future trends are impossible to predict.

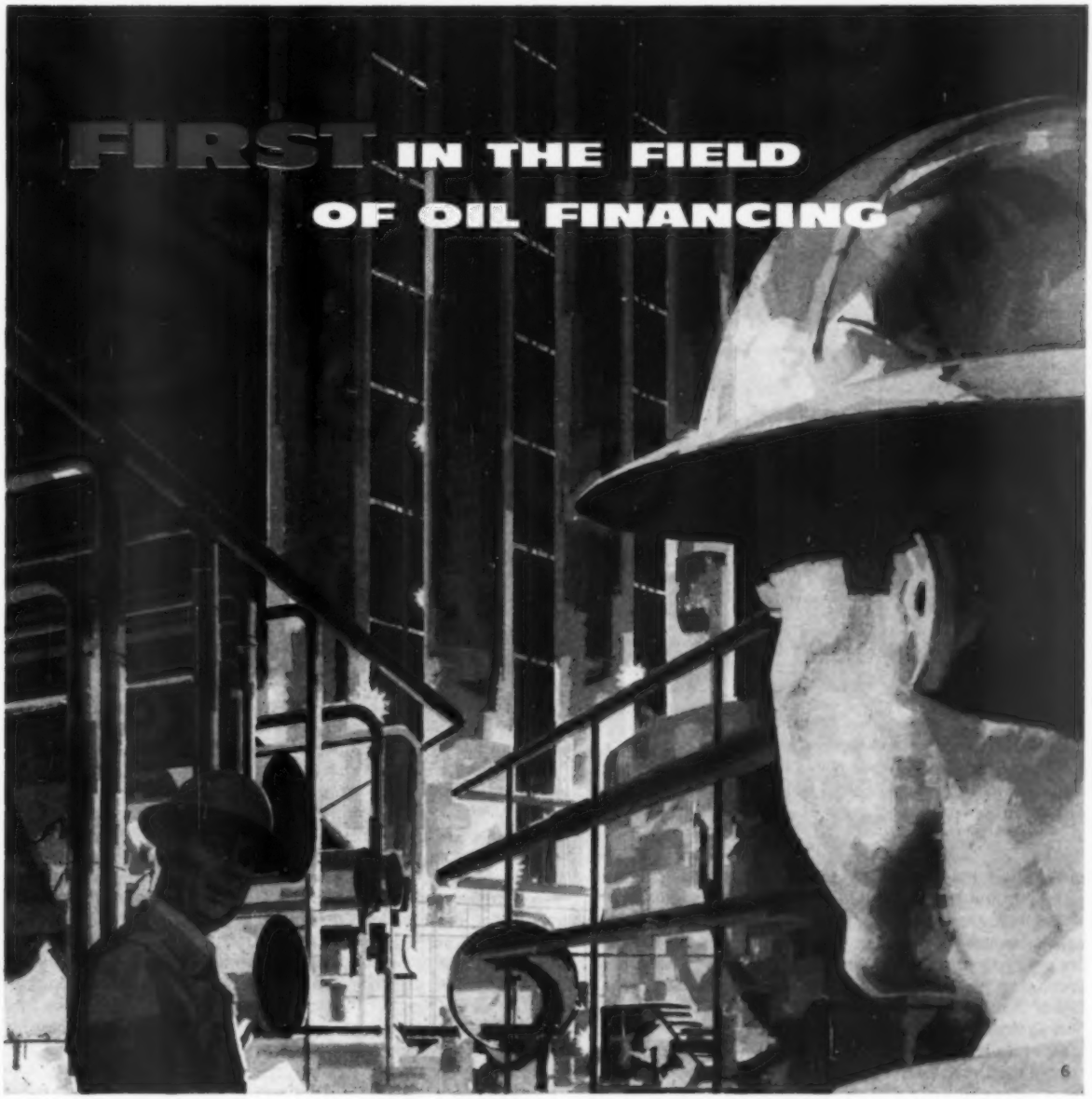
Each engineer must decide for himself just exactly what he wants and what he thinks he is. The superior engineer certainly doesn't wish to lower himself by associating with a group of predominantly mediocre engineers, but the poor or mediocre engineer will jump at the chance of collective security.

Part of this depends on our schools and the kind of engineers they turn out. The unqualified engineer may turn to collective bargaining to find security.

So long as there are collective bargaining organizations made up of engineers, the engineering profession will not advance as a true profession.

* * *

Reprinted from The Georgia Tech Engineer.



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Science Shapes U.S.A.

You need to get your feet on hard fundamentals once in awhile if you want to bounce higher in a changing world. Dr. James R. Killian, Jr., Special Assistant to the President for Science and Technology, recently examined the attitudes, values and motivations which have "given vigor to our technology and which are important to its continuing vigor."

In this excerpt he answers some questions about the blueprints of our society.

Does science contribute only to convenience and comfort of life and not to its quality?

What part do individual decisions play in our civilization?

How can we attract other nations to our belief in free institutions?

SO FAR OUR SOCIETY has demonstrated a sustained eagerness to find better ways of doing things. We have forged ahead because we wanted things to change.

The revolution of modern man — the revolution which has found its fullest expression here in the United States — lies essentially in this: It is a revolt against things as they are when there are ways of doing things better. It is a revolution based upon determination rather than determinism. It is a revolution against all the forces which hinder man in building a better life.

Science has had a major part to play in shaping this basic American faith in creative change and improvement.

The course of our nation has been deeply affected by the tenet very early embraced that nature could be put to work for the benefit of man, and that it is possible to wrest from nature a range of benefits to meet the needs of our people — that science and technology provide a means to advance the welfare of our people, and that this has been a better way to progress than through radical social change or ideological nostrums.

What Is Progress?

De Toqueville described "practical science" as a potent yeast in the American society of the early 19th century.

Eugene Holman once described our material progress as a stairway of advancement with progressively higher risers and narrower treads. Some observers are speculating as to whether our long ascent up this stairway is lifting our society to a new upper story of living; whether, in other words, our society may be approaching a transformation or new embodiment, representing a new order of creativity when man can achieve a new level of fulfillment for himself and the earth can be made to yield a sufficiency for all its people.

Still others liken the advancement of our society to pulling out a sticky drawer. We pull at one corner only to have it stick on the other side, but as we alternate pulls, it does come out, giving at one side or the other. All of us recognize the possibility of our progress' getting stuck at one corner from time to time, but most of us believe that it can be unstuck.

I do not suggest that we have any warranty, expressed or implied, that progress is inevitable or immutable; I only describe the deep-rooted American belief that progress is an achievable and worthy goal. I reflect my own intuitive belief that man has the capacity greatly to improve himself and his society.

Today we hear voices of doubt and pessimism, decrying or questioning the concept of progress. The increased currency of such phrases as the "illusion of progress" and the "corrosive effect of materialism" reflect an array of attitudes challenging the power of reason and the actuality of progress.

Is Progress Qualitative?

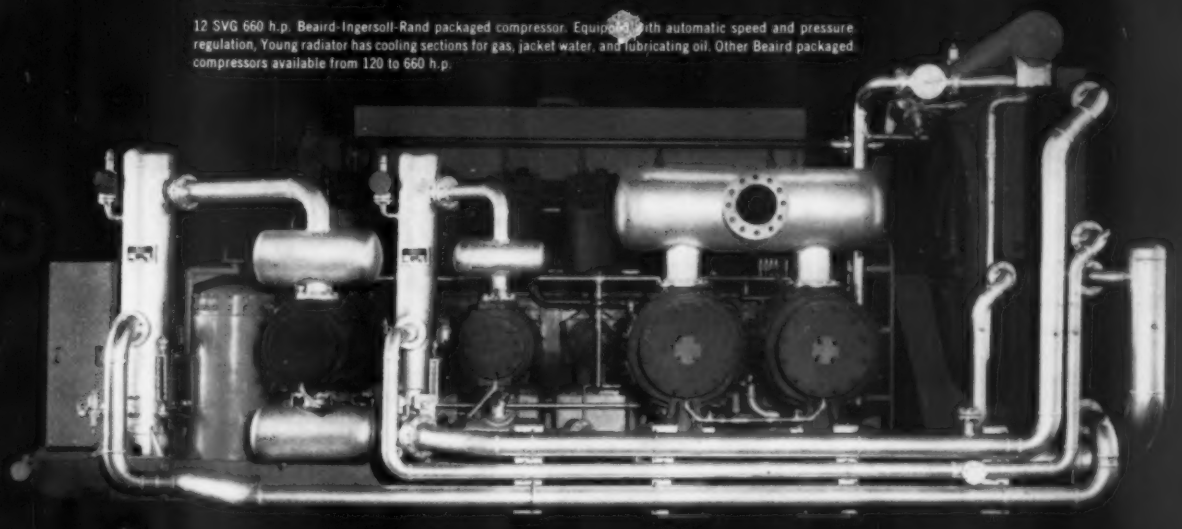
Technology and science are attacked as contributing only to the convenience and comfort of life and not to its quality.

In mentioning this attitude of doubt and pessimism, it is not my purpose to debate the theological or philosophical considerations on which they rest. My purpose is to express my contrasting faith that we can continue to draw the blueprints of a still greater society and that we can direct our advancing technology toward the realization of those plans.

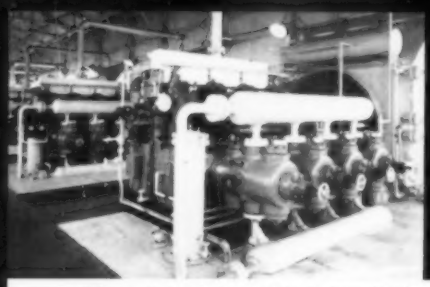
My purpose is to stress the importance of those aspects of technology which augment the quality as well as the quantity of life and things, which encourage individuality in the midst of standardization, which enhance man's excellence and dignity as well as his productivity.

If research is to continue to flourish and to give vigor and growth to our economy, these traditional American beliefs in the validity of progress become increasingly important. They are the wellsprings of that zest and audacity which have characterized our research and our economy in the past and, God willing, will continue to characterize them in the future. ➳→

4-CYCLE DESIGN

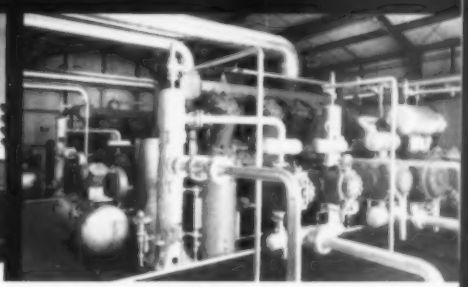


12 SVG 660 h.p. Beaird-Ingersoll-Rand packaged compressor. Equipped with automatic speed and pressure regulation, Young radiator has cooling sections for gas, jacket water, and lubricating oil. Other Beaird packaged compressors available from 120 to 660 h.p.



Carthage, Texas, plant equipped with three Beaird 8JVG 240 h.p. packaged compressors.

Sweetwater, Texas, plant equipped with one Beaird 10SVG 550 h.p. packaged compressor.



Tatum, Texas, plant equipped with two Beaird 10SVG 550 h.p. packaged compressors.

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Processes of Understanding

America's requirements can best be met by applying the best traditions of our own free institutions in a free economy. This is not a conference* to launch decisions on scientific or economic policies. This is a conference to discuss processes by which uncounted numbers of individuals and groups can understand mutual problems and thus achieve better decisions to guide their own endeavors in the light of better understanding of the problems of others.

This kind of decision-making takes longer and calls into play an understanding of social processes and the maintenance of horizontal lines of communications that authoritarian societies do not have to consider, and do not even include in their store of scientific knowledge. Our dynamic in research and development, as in other dimensions of our civilization, rests on many individual decisons taken in awareness of decisions made by others.

Creativeness and Education

Thus our economic and scientific dynamic is comprised of many interacting individual motivations and efforts. A factor that we cannot overlook is that our supply of individuals educated and trained — and our creative minds, bears directly on this economic and scientific potential.

Education — too — is an old theme in American social thought, but one we may have taken so for granted that we have forgotten its indispensability. Under-investment in education in any of our branches of knowledge and at any stage of the learning process means dwindling of our power at its very source.

We all believe that a free society of individuals need not apologize for its achievements — in either the short or the long run. We have added first health, then comfort, then leisure to the standard of living of our own and other peoples of the world.

To other nations, though — in those now taking seven league strides from feudal agrarianism into the atomic age, and striving toward our material standards — this belief in our free institutions is not so obvious nor unquestioned.

How successful we are in gaining their free commitment to our values will depend not only on how well we follow our own best traditions in leading by example, but also on how imaginatively we apply our technological assistance to their own environmental resources and their own social skills.

*Statement was made before Conference on Research and Development and Its Impact on the Economy, National Science Foundation, Washington, D. C., May 20, 1958. ★ ★ ★

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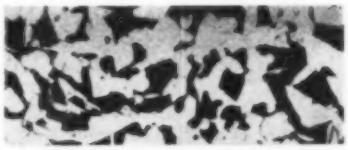

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GRAIN SIZE AFTER FORGING

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IS IT A SIN TO MAKE A PROFIT?

The U. S. economic system cannot live without earnings, yet people in high places undermine capitalism by attacking profits as if they were immoral and illegal

Bennett S. Chapple, Jr.

EVEN THOSE UNTUTORED in economics agree that a company takes in dollars for the products or services it sells and pays out dollars for the products and services it uses. In the long run, if it takes in more than it pays out, a profit results.

At present, unfortunately, it has been our experience that there is an alarming trend in public opinion and even among some employee groups to believe that there is something illegitimate about making a profit. We are somewhat disturbed that so few people seem to know the real purpose or value of profit. Much of this lack of understanding is spurred on from high places in government and some union circles. In fact, predicated on testimony before certain Congressional Committees, it would appear to be a sin to make a profit.

Quite likely the man on the street and the housewife in the super-market would insist they know the full meaning of free enterprise, yet they often are quite vague as to what profits are used for and how important they are to our free enterprise system.

They many times fail to realize that a year-end balance in favor of the company may be paid out partly for the use of the stockholders' money and partly to maintain, replace, or expand present and future facilities. It does not, indeed, go into the board chairman's safety deposit box. In fact, at United States Steel in 1957 our top officers and directors—approximately 60 in number—got less than one-third of one percent of the total payroll and the employees got $10 for every $1 that went to the shareowners.

Mr. Chapple is administrative vice president—commercial of United States Steel Corporation. This excerpt is from a speech, "Not Just Any Road" he gave before the American Institute of Chemical Engineers, Salt Lake City, Utah, September 23, 1958.

For some reason, people seem to forget that companies, in reality, are only a grouping of people. Neither could survive without the other.

It has been all too easy to lose sight of the importance of profit. During much of the period following the Second World War many companies and industries enjoyed their most fruitful years. But in the excitement of our blossoming economy, profit-awareness was often lost in the shuffle. When the level of business activity began to falter, as it did last year, the rose-colored glasses suddenly steamed up a bit. There was good reason for the atmosphere to become somewhat foggy.

Fortune magazine, in its recent review of the 500 largest industrial corporations, pointed out that 245 had decreased earnings in 1957, although 124 of these had actually increased sales in the face of their declining profits! This observation, if analyzed carefully, naturally brings great concern to anyone sincerely interested in the welfare of the business community.

The past several months have been a period of soul-searching for management. It is curious that when the nation should have been alerted to the objectives and need for profit so that industry could remain healthy and vigorous, it was instead distracted by a propaganda campaign—conscious or otherwise—emanating from Washington to the effect that inflation, recession and other economic ills were caused by the pricing policies of American industry.

I'm sure you recall that the attack was concentrated on the steel, automobile and oil industries, some of the members of which were called before a Congressional committee and subjected to a personal attack. The harvest of political hay turned out to be considerablely less than expected.

In the case of steel, the record was clear and indisputable, although ignored by the majority report, that the industry was not the primary cause of inflation. Hidden behind the veil of propaganda in the majority report and press releases were the facts clearly established in the hearings that wage rates at United States Steel have advanced at the rate of 8 percent compounded annually, while productivity has slogged along at an annual increase of less than 3 percent.

The truth was that the effect of a rise in the price of steel—or of any other basic material—is so insignificant in comparison to the overwhelming importance of a rise in wage costs, that it is not—and never can be—a controlling, or even a dominant factor in the price of finished articles.

An objective pursuit of this line of inquiry might have proved beneficial. Instead, the attack on profits tended to cloud the vision of the public and industry and divert attention from the essential importance of profit at a most critical moment in the history of our free enterprise system.

Now I want to avoid being pedantic on the subject of profit. Textbooks have been written about it, and past exhortations have been more eloquent than mine.

At United States Steel, while recognizing that ours is a profit-and-loss economy and that all operations cannot be run at a profit all the time, we are always aware of the importance of profits in our business and in the economy as a whole. We have to live with the practical application of profit principles and understand that words alone do not automatically lead to black ink on the ledger of success.

We know that the lack of profits, and of adequate profits, can snuff out the American dream. * * *

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Burgess-Manning Pulsation Snubbers, installed in the discharge laterals, effectively eliminate a costly 15 year old pulsation problem.

The four horizontal gas engine driven air compressors at the plant of a glass company presented a puzzling and costly pulsation problem from the time they were first put in operation. Numerous pipe line breaks occurred due to mechanical fatigue caused by gas pulsation. Bracing, the installation of expansion joints and other remedial measures tried from time to time proved ineffective.

Finally, after years of unsuccessful efforts to correct this violent pulsation condition at a substantial cost, Burgess-Manning engineers were called into consultation. The condition required the design and construction by Burgess-Manning of special snubbers that were installed in the 45 psig pressure discharge laterals adjacent to each compressor.

As a result, for the first time in 15 years, pulsation in the air lines was reduced to a satisfactory level, and the costly and damaging vibration in the discharge headers and after-coolers was completely eliminated.

The Burgess-Manning Company, through its long experience in this field, is equipped to analyze such problems and engineer an effective solution.

Burgess-Manning Snubbers Vary Greatly in Size

Depending upon the particular job to be accomplished, Burgess-Manning Snubbers are built in an extremely wide range of sizes. Some exhaust snubbers are as small as 4½" in diameter for installation on a 1" exhaust line. The other extreme is the specially designed snubber recently engineered to silence the exhaust of a 5000 KW Gas Turbine Generating Unit, which measures 74 ft. in length and 12 ft. in diameter and is believed to be the world's largest.

This is a cross-section of a snubber typical of many styles designed and built by Burgess-Manning to eliminate pulsation in gas and air pipe line systems or exhaust noise from internal combustion engines, blowers, turbines, compressors, etc.

SEND US a brief outline of your pulsation or exhaust noise problems and we will gladly send you pertinent literature

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Meetings

Mar. 16-18—**WPRA**, 47th annual meeting, Hilton Hotel, San Antonio, Tex.

Mar. 16-19—**AAPG-SEPM**, 44th annual meeting, Memorial Auditorium, Dallas, Tex.

Mar. 16-20—**AIChE**, Chalfonte Haddon Hall, Atlantic City, N. J.

Mar. 16-20—**NACE**, 15th annual conference and exhibition, Sherman Hotel, Chicago, Ill.

Mar. 17-19—**NACE**, 1959 Corrosion Show, Sherman Hotel, Chicago, Ill.

Mar. 18—**PESA**, Eastern district, Duquesne Club, Pittsburgh, Pa.

Mar. 23-24—**Theory of Fluid Flow Through Porous Media**, Conference, University of Oklahoma, Norman, Okla.

Mar. 25-27—**API Division of Production**, southern district meeting, Roosevelt Hotel, New Orleans, La.

Mar. 31—**AIChE**, Philadelphia-Wilmington Section, Experience In Industry Symposium, University of Pennsylvania Campus, Philadelphia, Pa.

Mar. 31-Apr. 1-2—**Illinois Institute of Technology**, 21st American power conference, Hotel Sherman, Chicago, Ill.

Apr. 2-3—**Society of Petroleum Engineers of AIME**, Rocky Mountain petroleum section, 5th annual joint meeting, Casper, Wyo.

Apr. 5-9—**The 1959 Nuclear Congress**, Cleveland Auditorium, Cleveland, O.

Apr. 5-10—**American Chemical Society**, 135th national meeting, Boston, Mass.

Apr. 6-7—**Instrument Society of America**, 2nd National Symposium on Chemical & Petroleum Instrumentation, St. Louis, Mo.

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Apr. 7-8—**Gas Compressor Institute**, Liberal, Kansas.

Apr. 7-9—**Petroleum Industry Electrical Association**, annual meeting, Galveston, Tex.

Apr. 7-9—**Petroleum Electric Supply Association**, annual meeting, Galveston, Tex.

Apr. 8-10—**API Division of Production**, eastern district meeting, Penn-Sheraton Hotel, Pittsburgh, Pa.

Apr. 13-17—**Annual Safety Convention & Exposition**, Hotel Statler, New York City, N. Y.

Apr. 14-16—**Southwestern Gas Measurement Short Course**, University of Oklahoma, Norman, Okla.

Apr. 15-17—**National Petroleum Assn.**, semi-annual meeting, Hotel Cleveland, Cleveland, O.

Apr. 16-17—**Rocky Mountain Oil & Gas Association**, midyear meeting, Gladstone Hotel, Casper, Wyo.

Apr. 18-22—**PESA**, 24th annual meeting, Boca Raton Hotel and Club, Boca Raton, Fla.

Apr. 19-23—**ASME**, oil and gas power conference & exhibit, Shamrock-Hilton Hotel, Houston, Tex.

Apr. 22-24—**API Division of Production**, mid-continent district meeting, Herring Hotel, Amarillo, Tex.

Apr. 22-24—**NGAA**, 38th annual convention, Baker & Adolphus hotels, Dallas, Tex.

Apr. 23-24—**West Texas Oil Lifting Short Course**, Texas Technological College, Lubbock, Tex.

Apr. 24—**Society of Petroleum Engineers of AIME**, Gulf Coast Drilling and production practices meeting, Lafayette, La.

Apr. 26-28—**Texas Independent Producers & Royalty Owners Assn.**, 13th annual meeting, Baker Hotel, Dallas, Tex.

Apr. 27-30—**Physical Chemistry of Process Metallurgy**, international symposium sponsored by AIME, Pittsburgh, Pa.

Apr. 29-30—**WPRA**, southwest regional technical-industrial relations meeting, Hotel Paso del Norte, El Paso, Tex.

Apr. 30-May 1—**API Division of Production**, Pacific Coast district meeting, Biltmore Hotel, Los Angeles, Calif.

May 3-6—**LPGA**, annual meeting, Conrad Hilton Hotel, Chicago, Ill.

May 4-5—**IPAA** midyear meeting, Westward Ho Hotel, Phoenix, Ariz.

May 4-6—**API Division of Transportation**, highway conference, Dearborn Inn, Dearborn, Mich.

May 4-7—**American Geophysical Union**, annual meeting, Washington, D. C.

May 4-8—**API Safety & Fire Protection Committees**, 12th midyear meeting, Rice Hotel, Houston, Texas.

May 5-6—**AIME**, North Texas section, third biennial secondary recovery symposium, Wichita Falls, Tex.

May 6-8—**API Division of Production**, Rocky Mountain district meeting, Gladstone, Henning and Townsend hotels, Casper, Wyo.

May 7-8—**Society of Petroleum Engineers of AIME**, Permian Basin oil recovery conference, Midland, Texas.

May 13-15—**API Division of Transportation**, annual pipeline conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

May 14-23—**International Petroleum Exposition**, Tulsa, Okla.

May 17—**ASTM**, committee E-14 on mass spectrometry, Statler Hilton Hotel, Los Angeles, Calif.

May 18-20—**Instrument Society of America**, 1959 fifth annual symposium, Shamrock-Hilton Hotel, Houston, Tex.

May 27-29—**Gas Technology Short Course**, Texas College of Arts and Industries, Kingsville, Tex.

May 27-30—**API Division of Refining**, mid-year meeting, Statler Hotel, New York City, N. Y.

May 31-June 6—**Fifth World Petroleum Congress**, Coliseum, New York City, N. Y.

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Laugh with Barney

Lambert was being sentenced by the judge for having hit his wife and mother-in-law.

"You will have to pay $550 ordered the judge. Lambert requested permission to ask a question. "I can understand the $500," he said, "but why the $50?"

"Amusement tax," replied the judge.

If there's nothing worse than a waffle
that's cold,
Or mashed potatoes five days old;
It's suddenly meeting an old fat hen
Whom you loved in school in 1910!

The instructor in atomic warfare asked his class of fire fighters: "What's the difference between 'radiation' and 'contamination'?"

The neophyte, fresh from the farm, thought for a moment and then came up with his answer:

"Radiation," he drawled, "is when you *smell* manure. Contamination is when you *step* in it."

A man pays a luxury tax on a leather billfold and an income tax on the stuff he puts into it and a sales tax when he takes out the stuffing.

Why worry about growing old? When we stop growing older, we're dead!

There isn't much to see in a small town, but what you hear makes up for it.

The Frenchman and the New Englander were traveling on an ocean liner and struck up an acquaintance.

"I understand," said the Frenchman, "that when you New Englanders haven't anything else to do, you spend your time tracing your family tree back to your great-grandfathers."

"Yes," nodded the New Englander, "and I understand when you Frenchmen have nothing to do . . . you spend your time trying to find out who your father was."

There was a time when a fool and his money were soon parted. Now it happens to everybody.

Barney knows a fellow who has been turned down by so many girls he is beginning to look like a bedspread.

"Ma, here comes the insurance man again. Do you want to pay him or do I go out in the yard and play?"

A teacher in an Oklahoma school asked if any of her pupils were part Indian.

"I am, teacher," replied Tommy.

"What tribe?"

"Well, I don't think it was exactly a tribe," explained Tommy. "It was just a wandering Indian."

The father was sitting patiently in the dress shop listening to his wife and their young daughter argue over a new frock for the daughter's first big dance. The youngster wanted an off-the-shoulder creation and the wife kept insisting that she wasn't old enough for one. The father finally settled the problem.

"Well," he proposed, "Let her try one on. If it stays up, she's old enough to wear it."

A barber surveyed the slick hair of the young man who had just seated himself in his chair. Then he asked: "Do you want it cut or should I just change the oil?"

Worse than old and bent is to be young and broke.

A well-known star in Hollywood says she believes in early marriages. She always gets married before lunch.

Much worse than being a spinster is being a spinster's daughter.

News flash in Davenport, Iowa, paper: Newlyweds leave Davenport for Hot Springs.

Fashion: Something that goes out of style as soon as everybody has one.

"Hello, Darling," a business man said over the phone. "Would it be all right if I brought a couple of clients home for dinner tonight?"

"Certainly, dear," was the honeyed reply. "I'd love to have them."

"I'm sorry," apologized the business man after a lengthy pause. "I must have the wrong number."

After the family had increased to three it was decided to employ a girl as nursemaid.

"My husband is very particular whom we engage," said the mistress to the girl who applied for the job. "Are you faithful? Have you a kind and loving disposition? Will you . . . "

"Excuse me, madame," said the girl, "But am I to take care of the baby or your husband?"

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Most economical of the granular drying agents, Florite has a longer service life, gives a low dew point depression, and aggressively resists "poisoning effects" which permanently destroy adsorption qualities.

Natural gas, propane, butane, gasoline, air, nitrogen, carbon dioxide, refrigeration compounds—and a growing list of liquid and gaseous compounds—are successfully treated with superior drying efficiency by use of FLORITE DESICCANT.

We also have available Fullers Earth and bauxite-based adsorbents for all types of adsorption filtration, including economical decolorization, dehydration and purification.

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Management Personals

▸ **David A. Shepard,** a director of Standard Oil Company (New Jersey), was elected an executive vice president and a member of the executive committee. He began his 31-year association with the Jersey Standard organization in 1927 as a research engineer. He has been a member of the board of directors since 1951 after wide experience with the company's domestic and foreign affiliates. After serving as a research engineer at the Baton Rouge refinery of Standard Oil Company of Louisiana, now part of Esso Standard Oil Company, he worked on oil hydrogenation and product application problems until 1934 with what is now Esso Research and Engineering Company, Jersey Standard's principal research affiliate.

D. A. Shepard

Transferred to France, Shepard was European representative of the research organization until 1940 and subsequently became a technical advisor on foreign sales for Standard Oil Company (New Jersey) with headquarters in London. During 1942-43, Shepard was Petroleum Attache for the United States State Department at the U. S. Embassy in London. In 1943, he was appointed a shareholders' representative for the company in the United Kingdom, and in 1945 was elected chairman of the board of the Anglo-American Oil Company, now Esso Petroleum Company, Ltd.

In 1949, he returned to the U. S. as executive assistant to **Eugene Holman,** then president. He served in that position until elected to the board.

▸ **Gilbert W. Humphrey,** president and director of The Hanna Mining Company, **Ogden Phipps,** chairman of the board of Bessemer Securities Corporation, and **Dwight P. Robinson, Jr.,** chairman of the Massachusetts Investors Trust, were elected directors of The Texas Company.

▸ **Dudley Tower** (vice president of Union Oil Company) was elected president of the Petroleum Club of Los Angeles. **Earl Hightower,** (partner in the law firm of Hightower, Gregg and Garland) vice president; **Gordon D. Campbell,** (assistant comptroller, General Petroleum) treasurer; and **Richard Sneddon,** (club manager) secretary.

It was announced also that three new directors were elected for a 3-yr term, namely, **Fred B. Behrens,** assistant to the vice president, Richfield Oil; **R. A. Keans,** president, Keans, Springman & Stipek; and **E. Pick McIver,** consultant.

▸ The 1958 Frank Newman Speller Award will be made to **Aaron Wachter,** director of research, Shell Development Corporation. The award is made in recognition of achievements in corrosion engineering by the National Association of Corrosion Engineers, Houston, Texas.

▸ **John H. Douma,** manager of joint operations for Sunray Mid-Continent Oil Company, was named vice president and manager of the company's West Coast division, Los Angeles, succeeding **F. W. (Dick) Borden,** resigned.

Douma will be returning to the California division where he first joined the company in 1938 as a field production engineer. In 1946 he was transferred to Tulsa general offices, becoming successively staff engineer, assistant general superintendent, general superintendent, and in 1954 was named manager of engineering services for Sunray. He became manager of joint operations in 1956, and has been responsible for oil and gas production dealings with other operators.

Robert W. Griffith was named to succeed him. Since August 1956 Griffith has been a special production department assistant to **R. E. Foss,** senior vice president directing production.

Stanley D. Breitweiser was elected executive vice president of marketing for D-X Sunray Oil Company, and **Harry A. Brown** and **J. Paul Greve** were named directors.

▸ **Dr. Richard V. Hughes,** an industrial petroleum engineer and former head of the department of petroleum engineering at Stanford University, has been named full professor of petroleum engineering at the Colorado School of Mines. **Troy F. Crowder** was named assistant to the president for public relations and development at the Colorado School of Mines. Crowder replaces **Dr. G. Duncan Wimpress,** former assistant to the president who recently assumed the presidency of Monticello College, Alton, Illinois.

▸ **George S. Buchanan** was elected senior vice president of Husky Oil Company. He has been vice president—production. **James C. Gilbert,** formerly assistant to the vice president—production, is new manager of appraisals and economics, and **Roland F. Cowley,** formerly acting district production clerk at Cody, is named administrative analyst in the office of the president, **Glenn E. Nielson.**

▸ **Ellen M. Vaughan,** Carter Oil, president of Desk and Derrick Clubs of North America, has announced the chairmen of standing and special committees for 1959. *Standing Committees:* Public relations—**Helen Little,** Carter Oil; program—**Doris L. Heee,** Ohio Oil; finance and budget—**Fae Matson,** Gulf Oil; statistical—**Nell Hagaman,** Shell Oil; membership—**Virginia Auer,** American Petrofina; rules—**Zetta Belle Gregg,** Independent Oil Producers' Agency. *Special Committees:* Convention — **Julia Simpson,** Skinner Corporation, and **Doris Post,** *Rinehart Oil News,* chairman and co-chairman, respectively; handbook—**Lois Giltner,** Cit-Con Oil.

Editor, *Oil and Gal* is **Gladys Watford,** Texas National Petroleum; editor of scrapbook, **Jerry Benge,** Texas Gas and Transmission.

▸ **Forrest S. Warren** is to be president and director of the Texas Petro Gas Company. In addition to Warren, other directors of the company are **Henry Groppe,** a partner in the firm, Mares and Groppe, and **John H. Crooker Jr.,** a member of the law firm, Fulbright, Crooker, Freeman, Bates and Jaworski. Warren has resigned as vice president of the Texas Natural Gasoline Corporation where he was in charge of its Gulf Coast division.

▸ **John R. Hannan** was named office manager for Sun Oil Company's Gulf Coast division at Beaumont, Texas. He succeeds **Sidney C. Shockley,** who retired January 1. **George A. Burleson,** formerly supervising auditor, replaces Hannan as assistant division office manager.

▸ **Leonard Raymond,** chief automotive engineer for research at Socony Mobil Oil Company, Inc., was elected president of the Society of Automotive Engineers.

▸ **Frank D. Lortscher** was named vice president in charge of crude oil sales of Signal Oil and Gas Company. Newly-elected directors of Signal were **Russell H. Green Jr., Forrest N. Shumway,** and **Arthur P. Williams.**

▸ **R. H. Brown,** manager of the corporate records division, was named manager of the newly consolidated corporate records and insurance divisions, Ohio Oil Company. **F. L. Fox,** vice president and manager of the contracts and insurance division, has retired after more than 43 years of service.

Chester E. English, assistant treasurer and manager of the corporate funds division has also retired after 42 years service. Succeeding English will be **Carl F. Stubbe,** assistant treasurer and supervisor of the banking department. **A. L. Brann,** supervisor of the loans department, was appointed assistant treasurer and supervisor of the banking department.

▸ **Mark M. Shumard,** auditor, Sinclair Oil & Gas Company, Tulsa, was elected to membership in the Controllers Institute of America.

▸ **Ben F. Vaughan Jr.,** Corpus Christi oil man and attorney, was elected to the board of Victoria Bank and Trust Company.

▸ New directors of Texas National Bank of Houston are: **Harold Burrow,** executive vice president, Tennessee Gas Transmission Company; **Kline McGee,** senior vice president of the bank; **A. W. Tarkington,** senior vice president of Continental Oil Company; and **J. W. McLean,** president of the bank.

▸ **W. L. Pickens** was elected vice chairman of the board of Preston State Bank in Dallas. He is one of the founders and a director of TIPRO.

▸ **Arnold Waller,** formerly petroleum manager, was named vice director of refining operations and oil production, Midland Cooperatives, Inc. **Ronald E. Ewing** was appointed director of budgeting and internal auditing. **Sigved Sampson** is named director of sales.

▸ **William F. Kenney,** vice president and general counsel of Shell Oil, is chairman of petroleum division of The Legal Aid Society's 1959 Campaign.

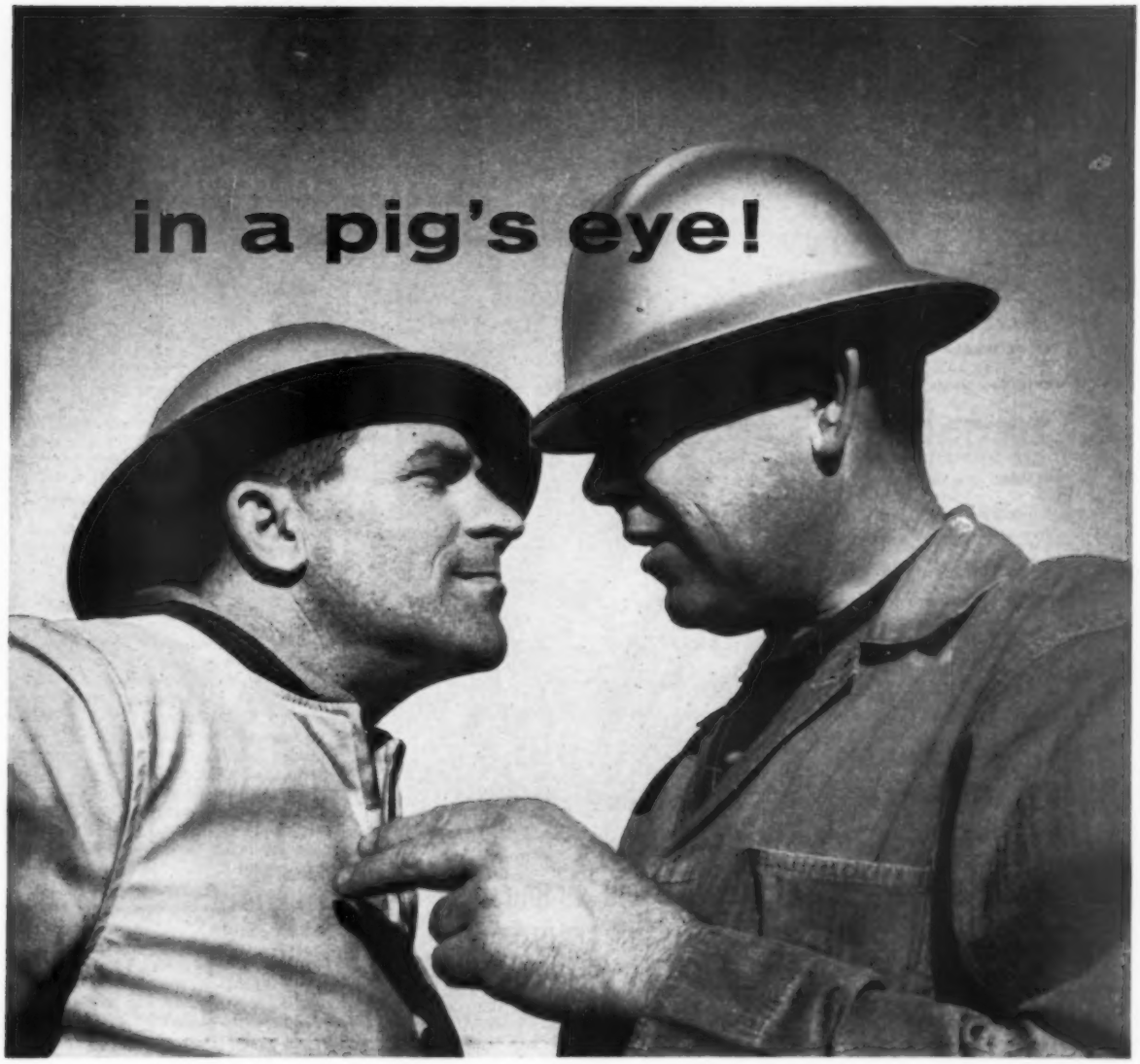
▸ **Richard A. Ny** was elected treasurer of Tidewater Oil Company. Prior to Ny's election, the treasurer's position was held by **Russell D. Richardson,** who continues as vice president-finance and controller.

John R. Rock is named employee relations manager and **Robert L. McKinnon** named assistant division employee relations manager.

Jack J. Leener was appointed non-divisional advertising manager of Tidewater. For the past 10 years Leener has served as a senior account executive for the Edward S. Kellogg Company, Strombergeer, LaVene, McKenzie Agency and West-Marquis, Inc.

▸ **W. Harold Rea,** president of Canadian Oil Companies, Ltd., director of the Bank of Nova Scotia, Interprovincial Pipe Line Company, Power Corporation of Canada, Ltd., and Canadian Power and Paper Securities, Ltd., is named host chairman for "Canada Day" of the International Petroleum Exposition.

▸ **Martin A. McNulty,** who rose from office boy to comptroller of Standard Oil Company (Indiana), retired February 1 because of illness, after 43 years' service. **William A. Underwood** will be promoted to succeed McNulty.



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The difference is Grove's compact body design. It permits a long, gradual taper of venturi valve hubs that gives you better flow characteristics than any other reduced opening valve. Ordinary valves have thicker bodies and a sharper taper of venturi hubs, causing increased line turbulence and resulting pressure loss.

Even with a port reduction of two to four basic pipe sizes, Grove Seal-O-Ring Venturi Valves have comparable flow capacity and pressure loss to so-called "full ported" rectangular port plug valves. And, they cost less too.

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WHEELING
COUPLINGS
FOR OIL COUNTRY USE

LINE PIPE COUPLINGS — ⅛" to 12" — Seamless — Black or Galvanized
PLAIN TUBING COUPLINGS A. P. I. — 1" to 4" — Seamless
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REAMED AND DRIFTED A. I. S. I. — ¾" to 12" — Seamless
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- AMPLE STORAGE: Contains 63-ft. chart roll, or 31 days' recording at one inch per hour. Useful chart width 2 5/16".
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- RECTILINEAR: Advanced design provides true rectilinear recording free from distortion.
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Personals

▸ **V. H. Ludwig** was elected a vice president of Gulf Oil Corporation. He will be responsible for organization planning and employee relations. In 1947 when the employee relations department was established, he was appointed general manager and later named director of that unit.

▸ **D. K. Dressback** was elected treasurer of Tekoil Corporation. He was formerly comptroller.

P. H. Bohart

▸ **P. H. Bohart** was made administrative vice president and coordinator of crude oil department for Gulf Oil Corporation. He is responsible for the administration of crude oil department worldwide affairs and for coordinating them with other departments concerned. He also is chairman of the Crude Oil Council and a representative on the company's Administrative Committee.

▸ **Bernard L. Majewski,** president of Great American Oil Company, has been elected to the board of directors of Universal Oil Products Company. Majewski fills the vacancy left by the resignation of **Fred C. Koch.**

▸ **John J. Scott,** assistant general counsel of Socony Mobil, New York, and **William G. King Jr.,** vice president of marketing, Richfield Oil, Los Angeles, were elected to the A.P.I. Committee on Public Affairs.

▸ **Thomas S. Horrocks** was elected a director of Sun Oil Company. He has been general sales manager since 1957, and will continue in that position.

▸ **L. C. Peschel,** controller of Mountain Fuel Supply Company, was elected a director, replacing **L. Clyde Olpin,** who resigned recently.

DEATHS

▸ **Wallace R. McClendon,** 70, who served as president of Halliburton Oil Well Cementing Company, from 1950 until 1953, died in McAllen, Texas, where he had lived the past 6 years. He entered the oil well cementing business and sold out to Erle P. Halliburton, the founder of Halliburton, in 1923. From that time until 1942, McClendon worked for Halliburton in the Gulf Coast area.

▸ **Roy E. O'Brien,** 60, field secretary of the American Institute of Mining, Metallurgical, and Petroleum Engineers, died January 9.

▸ **Charles Bernard Lundin,** 52, sales manager of the Dallas district of The Ruberoid Company, died January 20 after an illness of several months.

▸ **Wayne Eugene Larsh,** 42, general superintendent for West Texas Operations of G. W. Strake, Houston, was killed January 27 when his car was in a collision with a pipe truck.

▸ **John A. (Jack) Frost,** 62, deputy oil and gas supervisor with the United States Geological Survey in Artesia, New Mexico, died December 18, in Albuquerque after a long illness.

▸ **Charles S. Redding,** chairman of the board of directors and former president of Leeds & Northrup Company, Philadelphia, died January 2 after a brief illness.

▸ **C. E. McClure,** vice president of Lorac Service Corporation, a subsidiary of Seismograph Service Corporation, died suddenly January 4.

▸ **George Bean,** director in charge of sales for Homco died in Houston January 2 after a long illness.

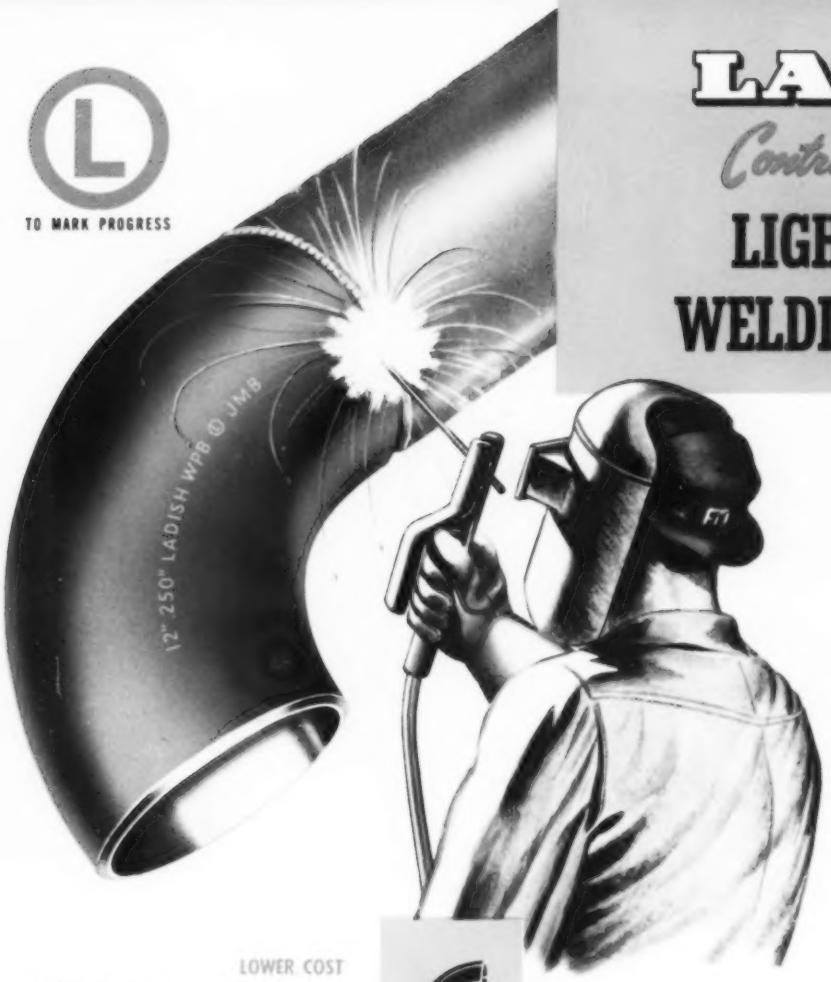
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

TO MARK PROGRESS

LADISH

Controlled Quality

LIGHT WEIGHT WELDING FITTINGS



developed for economical, dependable low pressure piping systems

LOWER COST

Substantial savings realized in purchase price of fittings and pipe.

REDUCED WEIGHT

Important weight reductions achieved by reducing wall thickness to correspond with service requirements.

GREATER FLOW

Larger inside diameter provides increased flow capacity.

EASE OF INSTALLATION

Reduced weight facilitates handling . . . speeds installation.

AVAILABILITY

Stocked in sizes 4" through 24". Wall thicknesses range from .188" to .250".

CONFORMITY TO SPECIFICATIONS

These fittings meet all requirements of ASA Code for Pressure Piping B31.1—1955 and B31.1.8—1955, ASTM A234 and ASA B16.9.

Lower purchase cost . . . reduction in weight . . . economy and ease in installation . . . increase in flow capacity—these are multiple advantages gained in using Ladish Light Weight Seamless Welding Fittings.

These Light Weight Fittings have been developed and produced under rigid metallurgical and manufacturing standards as part of a continuing program to meet the specific needs of industry for economical, functionally designed fittings.

Specification sheets on Light Weight Welding Fittings and Flanges available on request.

TO MARK PROGRESS

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SALES OFFICES: Amarillo • Atlanta • Baton Rouge • Buffalo • Calgary Chicago • Cincinnati • Cleveland • Denver • Havana • Houston • Los Angeles Mexico City • Montreal • New York • Odessa • Philadelphia • Pittsburgh St. Louis • St. Paul • San Diego • San Francisco • Seattle • Toronto • Tulsa

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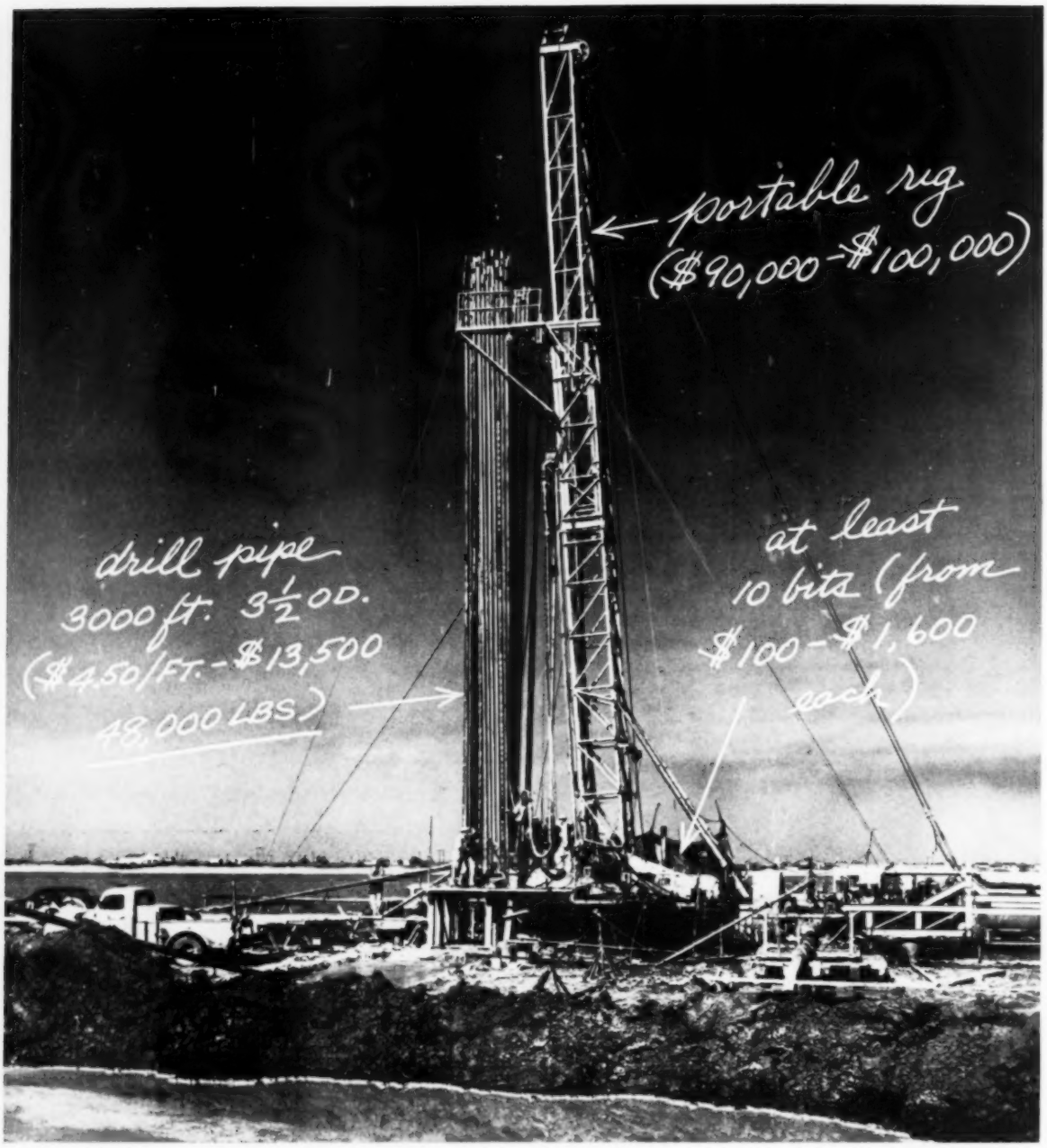
LADISH...THE FITTINGS LINE THAT OFFERS COMPLETE SERVICE IN TYPES, SIZES AND MATERIAL SPECIFICATIONS

WELDING FITTINGS	ASA & MSS FLANGES	SCREWED & SOCKET FITTINGS & UNIONS	LONG NECKS	LARGE DIAMETER & T.E.M.A. FLANGES



When you spend $90,000 for a drilling rig you've got to use the best rope available →

The best long-run, moneysaving rope. The high cost of portable drilling rigs excludes the "wise" buying of any rope below the quality level of Roebling Royal Blue. Anything less will cost you *more*, in replacements, delays, frustration.

Royal Blue is a product of America's oldest wire rope manufacturer. It is made from the toughest rope wire ever produced—Type 1105—extra high-strength improved plow steel. Preformed Royal Blue has a flexibility that curves around replacement costs and leaves them dormant. It is the strongest wire rope you can buy and use . . . for a long time.

You need exceptional resistance to shock, abrasion, fatigue and impact. You need around-the-clock ruggedness. Your Roebling distributor has what you need—Roebling Royal Blue. Get it and save. Wire Rope Division, John A. Roebling's Sons Corporation, Trenton 2, New Jersey, will send you details. Write.

ROEBLING

Branch Offices in Principal Cities • Subsidiary of The Colorado Fuel and Iron Corporation

• News
• People

The Trade PARADE

PETROLEUM ENGINEERS Milton M. Cooke and James E. Holden have announced the organization of a petroleum property management company. The firm

J. E. Holden

M. M. Cooke

will operate under the name of Cooke & Holden, Inc. and will offer a complete management service for producing oil and gas properties. Offices are at 1128 Bank of the Southwest Building, Houston, Texas. Mrs. Bernice Dowe Collis is secretary and office manager of the firm.

LYNN McGUFFY Company, Inc., is the new sales representative of the industrial silencer division of Burgess-Manning Company. From its headquarters in Shreveport, Louisiana, Lynn McGuffy Company will represent Burgess-Manning in southern Arkansas, northern Louisiana and northern Mississippi. In addition to Lynn McGuffy, Harry Tindel, vice president at Shreveport, and Carrol Bagby, sales engineer, with headquarters at Baton Rouge, will handle sales.

GARRETT OIL TOOLS division of U. S. Industries, Inc. has appointed two new agents to handle the sale of Garrett relief valves, diaphragm control valves, and industrial and pipeline equipment.

Belen-Lynn McGuffy Company, Ltd., of Calgary, Alberta, will cover Alberta, Saskatchewan, and Manitoba, and in the Fort Saint John area of British Columbia.

Hudson Engineering Company of Birmingham, Alabama, will cover Alabama, western Florida, southern Mississippi, and central Tennessee.

ROOTS-CONNERSVILLE BLOWER, division of Dresser Industries, Inc., Connersville, Indiana, is establishing a new district sales office in Houston, Texas. Manager of the new office will be Daniel Fulton. This new territory consists of Texas, Louisiana, and southern Arkansas.

GENERAL ELECTRIC computer department plans to expand its new Deer Valley Park plant before the new plant is fully occupied. Planned is an 86,400 sq ft addition to the department's 160 acre tract northwest of Phoenix.

BORG-WARNER is now manufacturing the mechanical shaft seal under the new B-W product division, Borg-Warner Mechanical Seals. The seal represents the success story of a B-W subsidiary product which recently became a separate Borg-Warner division.

BOWSER, Inc., Fort Wayne, Indiana, manufacturer of liquid handling equipment, now has exclusive sales rights in specified industrial areas to a liquid metering device, known as the "Pottermeter," and to other electronic controls and registering products manufactured by Potter Aeronautical Corporation, Union, New Jersey. There will be a new sales section in the Bowser marketing organization, to be known as the Bowser-Pottermeter division, to handle sales and sales engineering of liquid meters, electronic controls and registering equipment in industrial, petroleum, petrochemical applications. Bowser-Pottermeter will cover the United States and Canada.

OIL WELL SUPPLY AND SERVICE Company is planning to build a central warehouse, shop, and office facilities in Anchorage, Alaska; construction to start in May. The 15-acre site is on the Alaska Railroad, less than four miles south of downtown Anchorage and 2½ miles east of the Anchorage International Airport.

TEXAS INSTRUMENTS INC. plans to start construction on a 192,000 sq ft addition to the present 310,000 sq ft semiconductor-components division plant in Dallas. It will represent an additional investment of about $2,800,000, exclusive of the land. Contract for construction of the addition has been let to Robert E. McKee General Contractor, Inc., of Dallas. Architects are O'Neil Ford and Richard Colley.

VERNON, California, plant of U. S. Industries, Inc. has been sold to Bethlehem Pacific Coast Steel Corporation. Purchase price for the 290,000 sq ft plant was reported to be in excess of $1 million.

BJ SERVICE has opened a new field station in New Iberia, Louisiana.

FIVE OUTSTANDING petroleum engineering students at the University of Alberta, at Edmonton, Canada, were recent recipients of scholarship awards from McCullough Tool Company. They are F. C. Greaves, P. P. Kovacs, R. J. Russell, R. Mackett and G. R. Scott.

MANNING, MAXWELL & MOORE, Inc., announces the relocation of its nuclear and electronic process control product lines to Watertown, Massachusetts, with the exception of certain types of valves which will continue to be produced in the Stratford, Connecticut, plant. Electronic process control instruments, now manufactured in the company's Danbury, Connecticut, plant will be moved to Stratford.

DORR-OLIVER Inc. announces agreement with Salt Water Control, Inc. under which the latter firm adds the new Dorr-Clone Desanding System to its line of Dorr-Oliver process equipment. Headquarters in Fort Worth, Texas. Salt Water Control will offer this new system in New Mexico, Colorado, Texas, Oklahoma, Louisiana, and western Arkansas.

"AD MAN OF THE YEAR." Gerould A. Sabin, advertising director of the Colorado Fuel and Iron Corporation, was presented with the award, "Advertising Man of the Year" at a recent meeting of the Advertising Club of Denver.

FOUR WHEEL DRIVE AUTO Company, Clintonville, Wisconsin, has celebrated its 50 birthday by changing its name to FWD Corporation. The name was changed in order to avoid the misleading connotations of the old name. FWD has not made an auto since 1912, and now makes many types of vehicles in addition to four wheel drive.

JONES & LAUGHLIN Supply Division has opened new sales offices in Los Angeles. R. A. Mercer is appointed city sales manager.

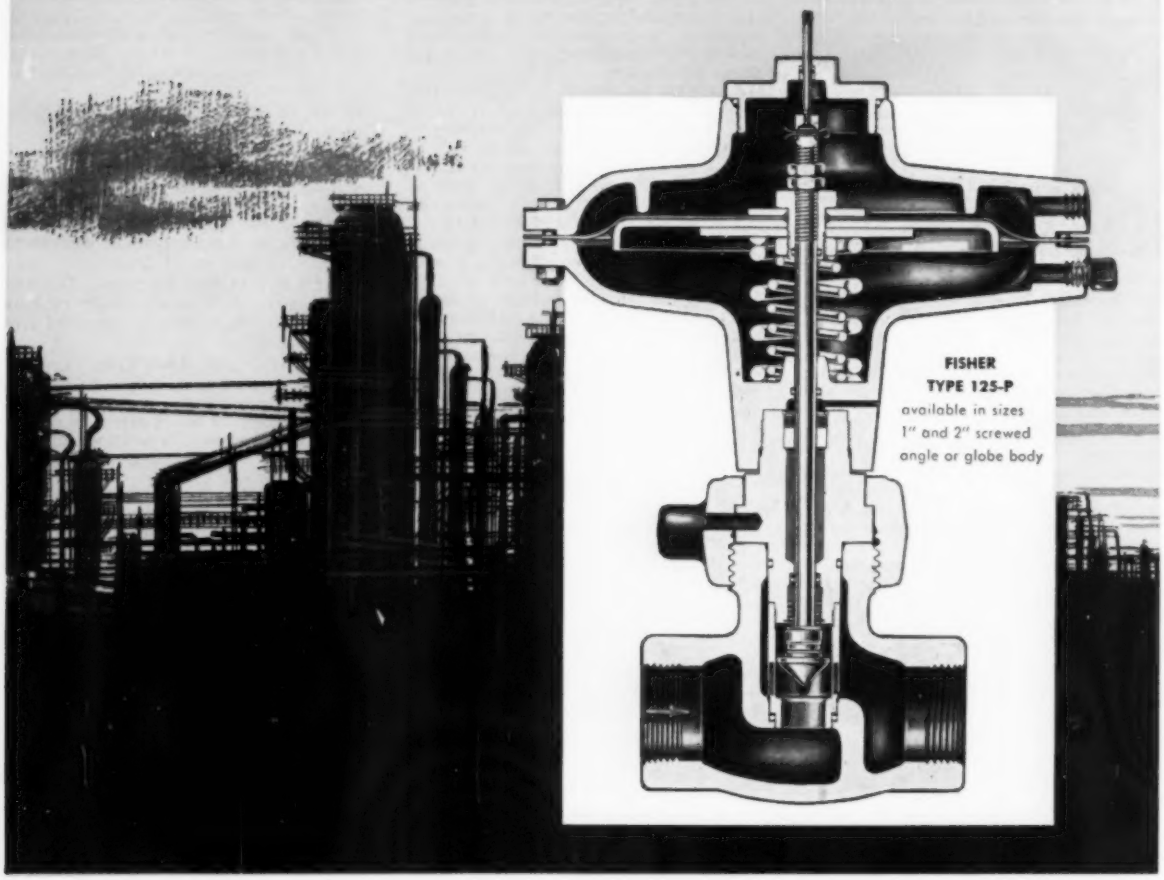
COLORADO OIL AND GAS Corporation has acquisited Jas. P. Marsh Corporation of Skokie, Illinois, manufacturers of pressure gages for liquid gases. All capital shares of the Marsh corporation, founded in 1865, were purchased December 1958 for $4,500,000.

There will be no changes in the Marsh operating personnel; however, changes resulted from the retirement of Conway H. Olmstead, chairman of the board, and Barrett Scudder, president, at the time of the sale. W. C. Norman, president of Colorado Oil and Gas, becomes chairman of the board. Alexander D. Rose, former vice president and general manager of Marsh, was elected president. Other directors are J. W. Smith, vice president and treasurer, John A. Thommes, vice president in charge of plant operations, Charles R. Kaufman, Chicago counsel for Marsh, J. S. Bowman, executive vice president of Colorado Oil and Gas, and C. W. McDermott, secretary of Colorado Oil and Gas who assumes the same position with Marsh.

Promoted to executive officers are R. E. Barnett, vice president for sales, and Bernhard Willach, vice president for engineering.

AN AGREEMENT to distribute products of the Rolo Manufacturing Company through Bethlehem Steel Company's Supply Division, is announced. Top officers of both companies gathered in Houston to participate in the consummation of the agreement. Left to right are J. V. Spalding, general manager of sales for Bethlehem, Tulsa; C. H. Seger Jr., assistant vice president and treasurer of Bethlehem, Tulsa; C. R. Zimmerman, vice president of Bethlehem, Tulsa; R. K. Franklin, president of Rolo, Houston; W. M. Boren, vice president of Rolo, Houston, and R. O. Branyon of Bethlehem, sales manager, Rolo Products, Houston.

Compact and versatile...



...a rugged field valve made especially for the oil industry

- Has rugged, heavy duty cast steel body that can take up to 3000 psi.
- You can interchange topworks with any other body in the series.
- You can get reversible topwork action with no additional parts.
- The single hardened steel inner valve fits all orifices.
- Diaphragm casings suitable for 50 psi operating pressure.

If you want to know more about the Fisher Series 125-P High Pressure Diaphragm Control Valve, send for Bulletin O-125P.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

FISHER® Controls

SINCE 1880

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SAVE
maintenance

SAVE
manpower

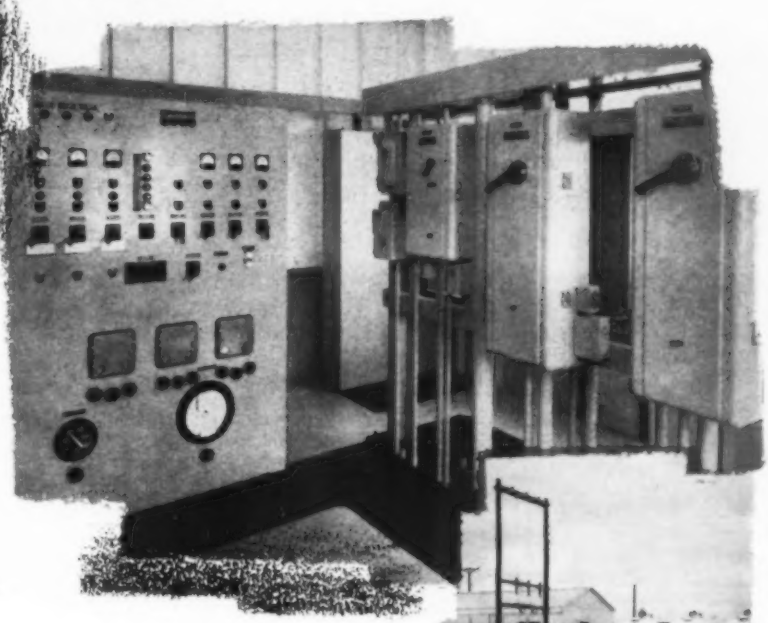
SAVE with Electric Operation

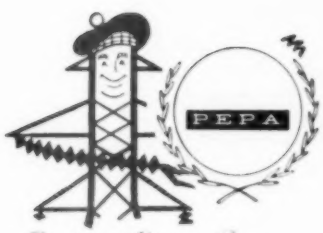
SAVE
money

This automatic electric control equipment designed and installed by a major oil company provides the greater flexibility of operation and dependability required for utmost economy in water flooding as well as remote control for field pumping. View at bottom shows 500 KVA transformer station supplying Purchased Electric Power to the pumping plant.

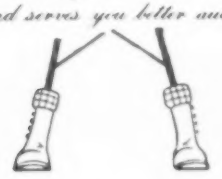
For information on savings Electric Power offers your operation, call your nearest Utility Electric Service Company or write us.

Three 100 HP, 440 V motors driving pumps supplying imput water





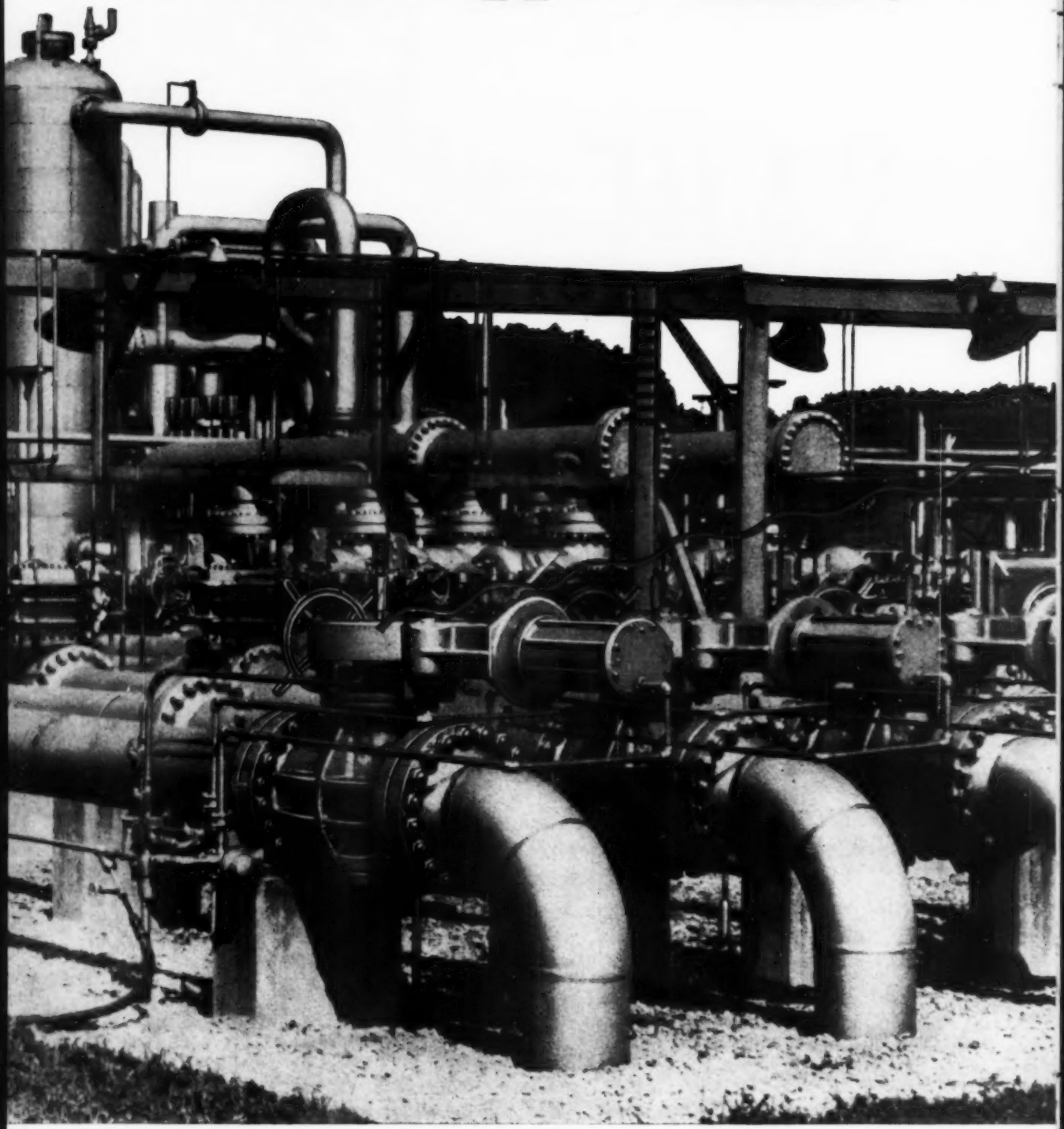
Purchased Electric Power . . . saves money, manpower, maintenance and serves you better automatically



Petroleum Electric Power Association

P.O. BOX 35006, DALLAS 35, TEXAS

It's what happens after you



ROCKWELL-

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push the button that counts!

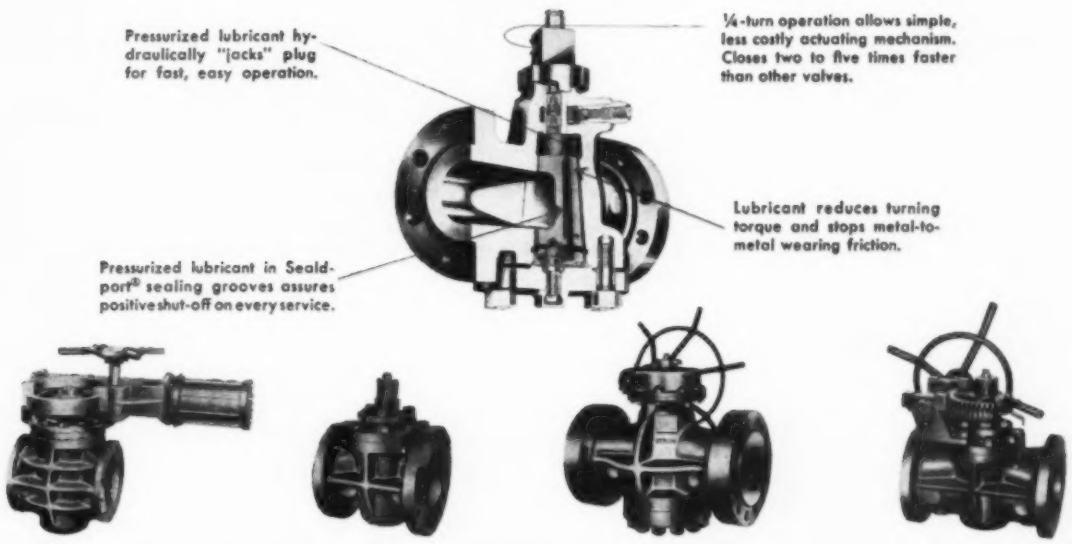
The new compressor station shown at the left is completely equipped for push button operation. But this kind of remote operation is only as reliable as the valves it activates. One stuck valve means inefficiency at least . . . catastrophe at most. That's why you always see Rockwell-Nordstrom lubricated plug valves where gas transmission and distribution men must have perfectly *dependable* control.

Rockwell-Nordstrom valves have proved ideal for automatic or remote operation because lubrication insures basic operating advantages that you can't expect in ordinary valves. See the drawing below for just a few of the reasons why these valves have been used in more gas industry installations than any other valve.

Rockwell-Nordstrom is the original and world's most complete line of lubricated plug valves. Available with electric motor, pneumatic and hydraulic actuations to meet any need. They cost no more to buy, often less, than ordinary valves and they save maintenance and down-time dollars everywhere they're used. For further details, write: Rockwell Manufacturing Company, Pittsburgh 8, Pa., Canadian Valve Licensee: Peacock Brothers Limited.

ROCKWELL-Nordstrom VALVES
another fine product by
ROCKWELL

LUBRICATION MAKES THE DIFFERENCE


Pressurized lubricant hydraulically "jacks" plug for fast, easy operation.
¼-turn operation allows simple, less costly actuating mechanism. Closes two to five times faster than other valves.
Lubricant reduces turning torque and stops metal-to-metal wearing friction.
Pressurized lubricant in Sealdport® sealing grooves assures positive shut-off on every service.

Nordstrom VALVES

AMERICAN®
GASCLOK
POWER DRIVE

Check these features--

- **Completely self-contained gas or air-powered instrument driving and timing unit for long, trouble-free operation in remote locations.**
- **Constant high power...more than 20 times the torque delivered by conventional spring-wound mechanisms.**
- **Timing accuracy continuous...no heavy "mainspring" to weaken or run down...unaffected by a ± 20% variation in supply pressure.**
- **Self-starting...no winding or priming of power unit.**

VERSATILE • ACCURATE
HIGH TORQUE DRIVE

- **Flexibility...ideal as original or replacement equipment for strip chart and conventional circular chart instruments.**
- **Built-in durability...timing mechanism internally sealed to prevent corrosion...large area internal ports prevent clogging.**
- **Rugged dependability...all power unit parts exposed to gas are aluminum or stainless steel...inherently explosion proof.**
- **Economical...normal air or gas consumption 5 cfh...operating pressure 5 psi...rotation 2 rpm.**

Then ask
your American representative how the versatile ***GASCLOK*** can provide new metering accuracies and economies for you.

AMERICAN METER CO

AMERICAN® METER COMPANY

INCORPORATED (ESTABLISHED 1836)

GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany • Alhambra • Atlanta Baltimore • Birmingham • Boston • Chicago • Dallas • Denver • Erie • Houston Kansas City • Los Angeles • Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle • Tulsa • Wynnewood • IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton • Regina

SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase and Welded Steelcase Meters • American-Westcott Orifice Meters • Instruments • Reliance Regulators • Apparatus • Valves

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

JONES & LAUGHLIN Supply Division, Tulsa, Oklahoma, has announced the completion of a modern store-office building to house their Shreveport, Louisiana, district office and store. Of steel and masonry construction, the building will house the district sales office for the North Louisiana-Arkansas district and the supply store for the Shreveport area. The building is divided into four main areas; the offices, store, warehouse and pump shop.

Completion of this store also completes the transfer of all Gardner-Denver mud pump parts to Jones & Laughlin stores.

KOPPERS COMPANY, Inc. will construct a new Research Center at Monroeville, Pennsylvania. Site development and initial construction of an administration building, 3 chemical laboratories, a power plant and supporting facilities are to begin in 1959 on the 176-acre tract of land near Pittsburgh.

UNION TANK CAR Company of Chicago has announced that Graver Tank & Manufacturing Company, Inc., of East Chicago, Indiana, previously a subsidiary of Union Tank, became a division of the company on January 1. There will be no basic change in the policy or method of operation of Graver Tank as a division.

GENERAL ELECTRIC Company two-way radio systems will be produced at Lynchburg, Virginia, where the G-E communication products department is transferring its headquarters.

GENERAL GAS Corporation and its wholly-owned subsidiary, Delta Tank Manufacturing Company, Inc., have moved into new joint executive offices in the Commerce Building at 300 Laurel Street in Baton Rouge, Louisiana.

GREAT BEND FISHING TOOL Company, Inc., Oklahoma City, Oklahoma, has joined the Petroleum Equipment Suppliers Association.

GARDNER-DENVER replacement parts for mud pumps are now available at all Jones & Laughlin Supply Division stores in Canada. J&L's Canadian installations include supply stores at Drayton Valley, Edmonton and Stettler, Alberta and at Estevan and Swift Current, Saskatchewan.

Halliburton Oil Well Cementing Company. Francis Anderson is the new manager of chemical research and development laboratories. He succeeds Hayden Roberts, pioneer Halliburton chemist who retired. Anderson was formerly assistant manager of the chemical research and development laboratories.

Phil Orr and George Walker will leave for Adelaide, Australia, early this year to open that firm's new "down under" operations. Orr will head the new venture. Walker will serve as an electrical service engineer.

Gates Rubber Company. Delbert L. Peterson was named general manager and C. William Gish named superintendent of the Nashville, Tennessee, plant.

McCullough Tool Company. W. H. Harvey was promoted to district sales and service manager of the Victoria, Texas, district. He was formerly an area salesman. David M. Glass has transferred from Luling, Texas, to Victoria as district sales representative. A. D. Wilson is now at Breckenridge, Texas, as district sales representative and Charles A. Marion is at Luling as southwest area salesman. Bill Rimes named district sales representative at New Iberia, Louisiana. Recently promoted to positions of district sales representatives were Jack N. Lawson, Salem, Illinois; Benjamin A. Newton, Hays, Kansas and Robert W. Sullivan, Olney, Illinois. L. M. "Pete" Oaks is appointed representative — fishing tool and wire line services. He was formerly district sales and service manager for Saskatchewan and Manitoba.

Rockwell Manufacturing Company. Willard F. Rockwell, Jr., president, will head a heavy machinery industry committee for fund-raising on behalf of the largest campaign of citizen education in foreign policy ever undertaken by private auspices in this country.

Axelson Division, U. S. Industries. Lester G. Evans was promoted to vice president in charge of sales. He was general sales manager. Donald L. Beeman was named buyer in the purchasing department. George G. Browning transferred to Shreveport, Louisiana; Jack L. Thompson to Casper, Wyoming; Hugh D. Wiles to Hobbs, New Mexico. They will head the sales and service organization in their areas.

The Pfaudler Company, a division of Pfaudler Permutit Inc. Lawrence C. Rodgers Jr., was named product manager, special metals fabrication. He was a member of the sales force in the Houston, Texas, area. Cloyd L. Betzer is the technical manager. He joined Pfaudler in 1957 as a member of the staff of the vice president in charge of manufacturing.

Petrolite Corporation, Tretolite Company division. Robert F. Owen, formerly assistant engineer, Core Labs joined the company as engineer in the South Louisiana district at New Orleans. Wallace Wayne Geddes, previously with Quinntanna Petroleum Company, is assigned to the Houston district at Pasadena, Texas.

Alan H. Brown, who has been on special assignment for the past year with Tretolite at the plant and main offices in St. Louis, Missouri, has been assigned to Eastern Venezuela as field engineer with South American Petrolite Corporation.

Sprague Meter Company. Bill Demenic was appointed new sales representative replacing James W. Smith in the Mid-West territory. His territory will include Nebraska, Colorado, Kansas, Missouri, and Wyoming.

Tennessee Coal & Iron Division, U. S. Steel. George D. Brengelman, formerly general superintendent of the Ensley Steel Works, was promoted to the general superintendency of the Fairfield Steel Works. Haran W. Bullard, formerly assistant general superintendent at the Fairfield plant, succeeds Brengelman. Eugene K. Graham, previously assistant to the general superintendent at the Fairfield steel plant, advances to assistant general superintendent of that works. Dudley Vaughan, formerly general superintendent of the Fairfield Steel Works, has retired.

Oil Well Supply, division U. S. Steel. William L. Powers Jr., assistant district engineer at Corpus Christi, Texas, was transferred to Houma, Louisiana. Andy C. McDonold, district representative from Ellinwood, Kansas, moved to Great Bend, Kansas. Harman Holcomb Jr., field representative from Brookhaven, Mississippi, also transferred to Laurel, Mississippi. Rowland E. Gano was named manager of the Greensburg, Kentucky, store.

Billy E. Smith was named district manager of the Neilsen Pump Works.

W-K-M division of ACF Industries, Inc. Robert D. Butler formerly assistant sales manager — plug valves, is appointed sales manager — plug valves.

Worthington Corporation. Jack B. Laramy was appointed manager of sales. He was assistant manager of the marketing division and Eastern regional sales manager, with Patrick L. McManus succeeding him. E. A. Murray is appointed manager of the newly combined sales and service at the compressor and engine division. Murray has been serving as manager of compressor sales. Replacing him is Everett L. Case. Case was assistant manager of compressor sales.

Well Equipment Manufacturing Corporation. George West is named South Louisiana representative, with headquarters in New Orleans.

Kerrigan Iron Works, Inc. Robert B. Eastty is named general sales manager of the Grating and Greulich Bridge Floor divisions. General sales offices will remain in New York City. He formerly served as sales manager of the Greulich Bridge Floor division.

World-Wide Instruments, Inc. Ross A. Pfaff recently joined the staff to head the firm's mechanical engineering, research and design department.

Youngstown Sheet and Tube Company. Richard J. Stamberger, formerly assistant district sales manager in New York, becomes manager of the new trade relations department. Robert W. Walling, from assistant manager to manager of high strength sales. Roy A. Curl, from manager of sales promotion to manager of sales promotion and advertising. Robert B. Davidson, from Cleveland district sales office to assistant manager of sales. Dean N. Frederickson, from Chicago district sales office to assistant manager of conduit sales; Herbert L. Furse, from St. Louis district sales manager to assistant manager of line pipe sales; Oscar H. Reuter, from resident salesman at Louisville, Kentucky, to assistant manager of standard pipe sales; Robert K. Stephens, carbon bar, rod and wire sales, to assistant manager of that department; William H. Stokes, tin plate sales to assistant manager of that department; Frank A. Anderson, from Chicago district sales office to district sales manager at St. Louis; John C. Clark, New York district sales office, to assistant district sales manager; William E. Fender, Indianapolis district sales office, to assistant district sales manager.

Paul M. Haas, retired as assistant comptroller after serving for nearly 35 years. He was succeeded by E. Ross Mateer, general auditor, who has been with the company since 1923.

Thomas G. Lewis was named purchasing agent. William B. Seeman was advanced to the position of group leader, buyer.

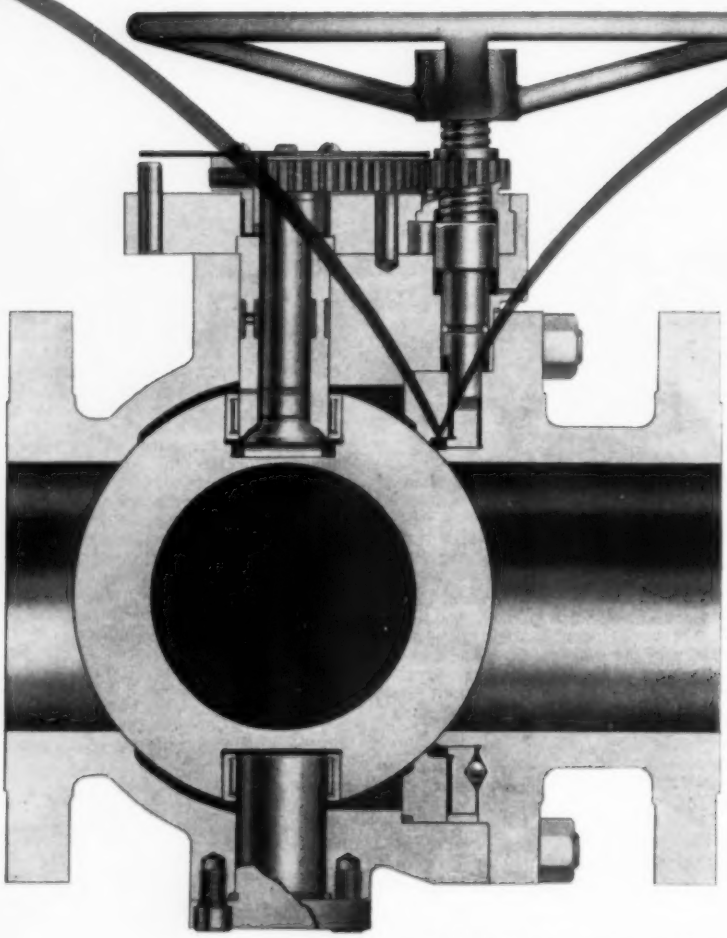
ACF Industries, Inc. Robert C. Richardson was named manager of organization. He will supervise salary administration and personnel.

Aero Service Corporation. Thomas O'Malley was named vice president in charge of the newly established marketing division. He previously headed the international air survey company's Canadian affiliate, Canadian Aero Service, Ltd. Homer Jensen will be director of a new development division in addition to his duties with airborne geophysics division.

Charles M. Hodell, vice president, is to head another new Aero division: Product sales. Other promotions include Charles B. Ermentrout Jr., formerly head of the accounting department and now assistant treasurer, and Eugene Cook, who was named assistant secretary. Cook had been administrative assistant to the treasurer.

HYDRIL BALL PLUG Type "K" VALVES

COMPRESSIBLE PORT SEAL
provides
POSITIVE SHUTOFF



Hydril Ball Plug Valves achieve a positive seal against pressure from either direction because the fully enclosed packing ring is *mechanically pressed* tightly against the spherical plug and its seat after the valve is closed.

No other valve has this *controlled* port sealing feature.

SEEP-PROOF, BUBBLE PROOF. The fully confined packing ring is tightly squeezed against plug and seat so that it flows into surface imperfections, around sediment . . . even closes scratches that may occur on the sealing surfaces.

PORT SEAL RETRACTS for easy operation. The mechanical pressure against the port seal is released before plug rotation commences to eliminate seal ring wear and assure easy operation.

•

Write for catalog describing Hydril Ball Plug Valves in full detail.

Another dependable Hydril pressure-control product

HYDRIL COMPANY

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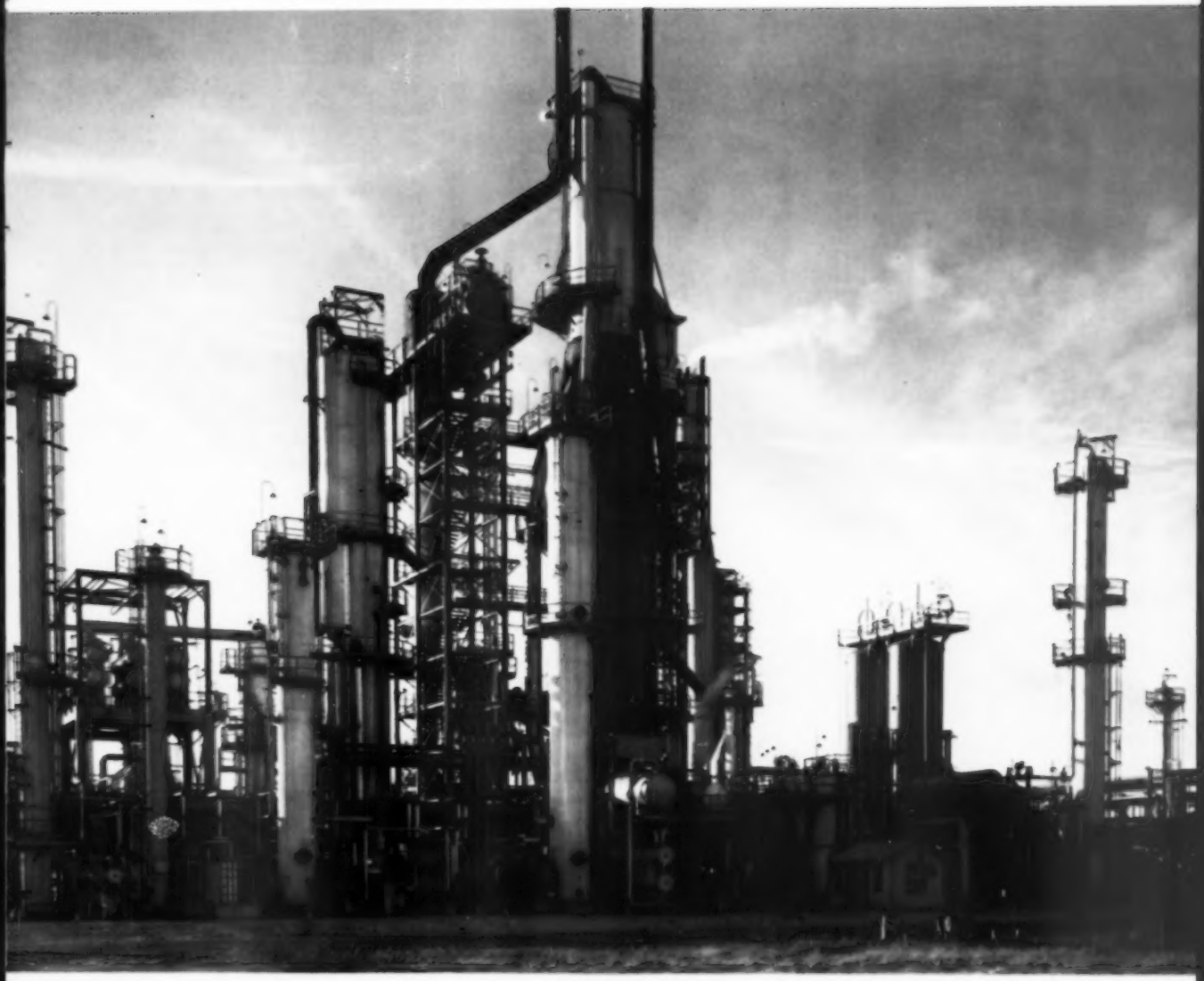
Sales offices: Bakersfield, Los Angeles, Ventura, California; Harvey, New Iberia, Louisiana; Oklahoma City, Tulsa, Oklahoma; Rochester, Pennsylvania; Corpus Christi, Dallas, Houston, Midland, Odessa, Texas; Casper, Wyoming; Farmington, New Mexico; New York, New York; Calgary, Edmonton, Canada.



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Looks quiet, doesn't it?

Yet inside, this new refinery is pulsating with life—surging with activity to produce fuel for millions of thirsty carburetors.

And pressure vessels like those shown above are being built day-in, day-out at Solar Chicago. Meeting rigid and unusual specifications is simple for us. It's all in a day's work.

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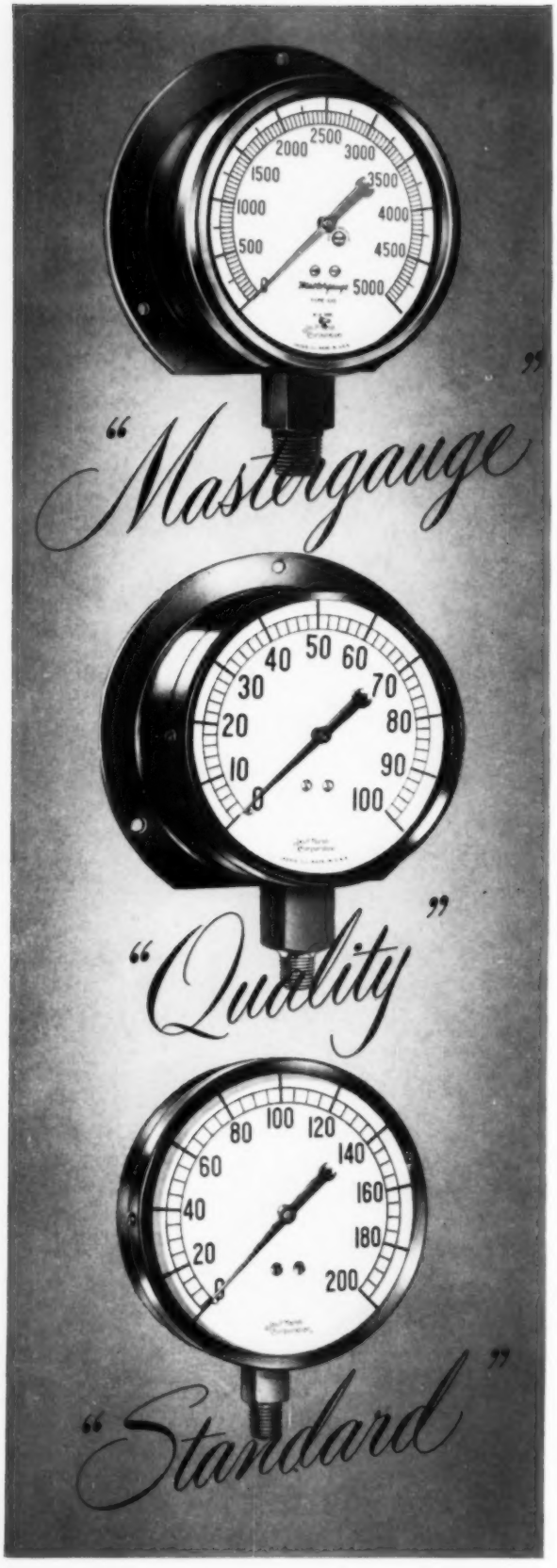
FORMERLY CHICAGO STEEL TANK CO.



What pressure gauge for your particular need?

The clear-cut economical answer to your specific gauge problem is right here in the Marsh line. It is here because the Marsh line contains the world's most complete range of gauges in the three broad brackets of gauge applications.

THE "MASTERGAUGE" GROUP...for those extreme services that demand the ultimate in gauge precision, accuracy and stamina.

THE "QUALITY" GROUP...also for tough conditions, but less severe than the conditions served by the "Mastergauge" Group.

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While these three brackets run a wide gamut of prices, the difference between them is not so much a matter of *grade* as a matter of *kind* and *purpose*. All gauges in all groups reflect Marsh precision and quality. Collectively they cover practically every conceivable gauge requirement.

The answer is in the catalog...but if you have a special problem let our engineering department work with you to select the most efficient, most economical solution to your problem.

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MARSH

"THE STANDARD OF ACCURACY"

American Steel Foundries. William V. Covert, chief engineer of Diamond Chain Company, a subsidiary, was transferred to the general offices of the parent company in Chicago as assistant vice president.

Allis-Chalmers Manufacturing Company. E. E. Strickland, formerly manager of industrial sales for the New York district, was appointed manager of general products division sales for the Northeast region. His headquarters will be in New York. R. H. Porterfield is new manager, industrial sales, New York district, and W. T. Farnsworth manager of the Hartford (Connecticut) district. Joseph Varacalli, formerly distributor supervisor for the Northeast region was appointed supervisor of original equipment manufacture and distributor sales for the New York district.

Three new sales posts were announced for the Detroit district: Earl R. Narum, manager of automotive industry sales; Roy E. Goodwill Jr., manager of general industrial sales, and Kenneth Womelsdorf, assigned to the district as a sales representative.

Baash-Ross Division of Joy Manufacturing Company. Wallace L. Reed was named area sales engineer and will work out of the Houston offices covering the Gulf Coast area. William F. (Bill) Krause Jr. is area sales engineer and will be located at the Oklahoma City office, and Wilbur F. Lane is in the company's Odessa sales office. James E. White Jr. is new design engineer in the home offices.

J. B. Beaird Company, Inc. Dawson Lary was promoted from sales engineer to district manager of the New Orleans office. He will be joined by N. J. Chamberlain, general products representative in Houston.

John L. Tullis was elected president and general manager of Beaird, Beaird International Inc. and The Phoenix Corporation.

Bethlehem Steel Company, supply division. J. V. Spalding is general manager of sales at Tulsa. H. L. Hawkinson Jr., to Gulf Coast division manager; R. O. Branyon, sales manager-Rolo Products, and W. J. Brady, division sales manager-projects.

Borg-Warner Corporation. Gordon Turnbull is named vice president and works manager. Frank Pilling is new vice president and general sales manager and Thomas P. ValRose manager of purchasing and planning for control rod mechanisms.

California Research Corporation. F. J. Fayers was appointed group supervisor of research in reservoir analysis and J. Earl Warren group supervisor in charge of reservoir engineering, both at the La Habra Laboratory.

R. L. Parsons is the new technical assistant to the vice president for oil field research. Named to succeed Parsons as supervisor, general services, at the company's La Habra Laboratory is D. L. Moore, industrial relations specialist of the San Francisco office general administration staff.

Cardwell Manufacturing Company. Don Rhoads was named special sales representative for Kansas and key oil centers in Oklahoma.

Century Geophysical Corporation. Robert J. Riggs Jr. is named manager, Seismic Reference Service division.

Crutcher-Rolfs-Cummings, Inc. John A. Schrawger was named western division sales representative with headquarters in Denver.

SEE FOR YOURSELF HOW

OSPHO®

PREPARES RUSTED METAL FOR PAINTING...

Brush or spray OSPHO directly on rusted metal. Let dry overnight.
Test the hard surface that results — the perfect base for paint.

Send for FREE Test Sample

Eliminate sand-blasting or flame-cleaning. Simply brush off loose rust and apply OSPHO on the rusted metal surface. One application *kills* the rust and provides a *sound* base for your regular maintenance paint. Rust action is stopped — paint jobs last much longer.

OSPHO is *not* a primer — *not* a paint. It is a carefully balanced phosphate chromate metal treatment which chemically changes rust (iron oxide) into iron phosphate — an inert, hard, gray surface ideal for painting.

OSPHO provides excellent coverage . . . a gallon treats up to 600 square feet. And cost is low. Available in 1-gallon containers (in cases of 4), 5-gallon pails, 50-gallon barrels. Colorless, non-toxic, non-flammable. Available through distributors.

Repeat orders over the past 16 years are proof of OSPHO's effectiveness. *See for yourself . . .*

Write Now For FREE Test Sample
(on company letterhead)
and descriptive literature

ONLY OSPHO KILLS THE RUST

TREATS NEW METAL TOO!
When applied on new ferrous metal, galvanized iron and aluminum, OSPHO imparts a slight etch to the metal, insuring tight bond of the paint coat that follows.

RUSTICIDE PRODUCTS COMPANY
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QUALITY MAINTENANCE PRODUCTS SINCE 1917

CORROSION IN WATER FLOOD PIPE LINES?

WATER FLOOD PIPE LINES can be protected from corrosive waters.

CEMENT MORTAR LINING of water flood lines can be done "in place."

WHERE CORROSIVE WATER is causing too frequent water line problems, Cement Mortar Lining is your answer.

And where raw water lines are being installed, Cement Mortar Linings are advisable, before the pipe goes in.

RESULT: Nuisance-free and trouble-free water pipe lines, for years.

PLUS SOMASTIC—for the best in exterior corrosion protection.

For immediate action, write, wire or phone

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Division of American Pipe and Construction Co.

Trade Parade

Consolidated Electrodynamics Corporation. William T. Kane was named contracts administrator and Robert E. Miller purchasing agent of Datalab, a division of CEC.

C. Kenneth Hines was made manager of analytical, process-control, and data-handling systems for the systems division.

Cooper-Bessemer Corporation. Samuel D. Greiner was named assistant product manager, motor-driven compressor sales. He will work directly under A. D. Goodson, manager of this section.

Dowell. M. E. "Cotton" Heslep, formerly sales engineer at Williston, was transferred to Riverton, Wyoming. V. D. Warnke is moving to Worland to be service engineer and G. A. Berry is moving from Worland to Williston as service engineer, replacing Warnke.

Ethyl Corporation. Leonard L. Huxtable was named manager of the Western region of the sales department. He succeeds Meredith Littlefield, who has been granted a leave of absence.

L. B. Foster Company. Four new sales representatives are Leonard A. McGovern, assigned to the New York office, and will cover the Philadelphia area; Richard P. Gurley named sales administrator of the construction products division of the Chicago office; Donald J. Cier joined the sales staff of the Los Angeles office, and will cover the Northwest; and John B. Manning will specialize in pipe sales in the Pittsburgh office.

General American Transportation Corporation. Jack I. Levy was elected a director, vice president and general counsel. He replaces the late Milton G. Manasee. Bruce S. Borland was elected treasurer. He replaces E. E. Schulz, retiring.

General Electric. John E. Strehle was appointed Southern Florida district sales manager at Pompano Beach and Jack Najork placed in charge of the two-way radio office in Chicago, for the communication products department.

Charles E. Elston was appointed general manager for the gas turbine department. Elston succeeds Lewis J. Burger who was named general manager of the switchgear and control division.

Genesys Corporation. Gifford K. Johnson was elected president. He was formerly vice president-production at Chance Vought.

Houston Oil Field Material Company. Z. C. Ambrose joined Homco as executive vice president. He had been with Associated Oil & Gas Company and was president of that company for the past year. He was also president of Prince Marine Drilling and Exploration Co.

Houdaille Industries, Inc. E. L. Spencer was named general manager and Gervase M. Magrum as assistant general manager of the Buffalo hydraulics division.

Cooling Tower Institute. Ennis C. Smith, Hudson Engineering Corporation, was elected to secretary, filling vacancy created by resignation of The Marley Company from CTI; and James P. Wiseman of Fluor Products Company elected to treasurer. Karl E. Johnson of J. F. Pritchard & Company of California continues as president and Ernest E. Goitein of Foster Wheeler Corporation as vice president of the national association of the major manufacturers of industrial water-cooling towers.

Joy Manufacturing Company. Robert W. Eager was elected vice president, manufacturing. He has been manufacturing manager.

Trade Parade

Johnston Testers. B. R. Dixon, formerly assistant to the president, will be new division manager of the Northern division, with headquarters in Denver. G. D. Duke, formerly assistant manager of field operations, will be the Southern division manager, Houston, Texas.

Kellogg Switchboard and Supply Company. Roy R. Marlowe was appointed manager of the newly re-aligned eastern regional office at Syracuse, New York. Marlowe was northeastern division manager.

Lufkin Foundry and Machine Company. W. T. Crowder, district manager of the East Texas area was elected chairman of the East Texas section of Society of Petroleum Engineers of AIME.

Roy Lilley Jr. was appointed general manager, with headquarters at Maracaibo, Venezuela, S. A., of Lufkin Overseas Corporation, S. A.

F. H. Maloney Company. H. Bruce Finch was elected controller. He was formerly associated in the oil properties business with his brother, Owen C. Finch.

Manning, Maxwell & Moore. John F. Reed and Arland R. Walkley were named vice presidents. Reed is general manager of the Consolidated Ashcroft Hancock division and Walkley general manager of the Shaw-Box Crane & Hoist division.

Midwestern Manufacturing Company. Ray O. Branam was elected vice president and director. He served as general manager in charge of engineering, production and sales for a year.

Mine Safety Appliances Company. John W. Moser was named sales engineer for the Kansas City, Missouri, territory of the technical products division.

Lee C. Moore Corporation. Ray T. Rigney was named field service manager. Assistant plant superintendent for 8 years, he will direct all field service operations and personnel.

Magnet Cove Barium Corporation. Kenneth C. Reed was named associate editor of *The Magco Scene*, internal publication. He was formerly associated with Perkins Distributing Company of Houston as sales manager.

Jones & Laughlin Supply Division. Major changes of sales personnel and sales districts include:

W. R. Layne, district sales manager of Southern Oklahoma district; J. K. Guinn, district sales manager and W. J. Whatley city sales manager of Central Oklahoma district; A. A. Hopper, district sales manager, Eastern Oklahoma district.

Kansas has Eastern District with J. A. Carrigan, district sales manager, Wichita; and Western District with J. A. Beaird sales manager, at Great Bend.

At West Texas District, Odessa, G. A. Whiteker is sales manager and at New Mexico District, Hobbs, R. L. Daniel is sales manager. Both are part of J&L's "Southwest region" under the direction of F. L. McFarland, regional manager, Midland. M. G. Burgeis is new regional salesman-drilling equipment at Midland.

Mississippi District has been included in J&L's "Gulf Coast Region," with D. T. Ottinger, regional manager, Houston.

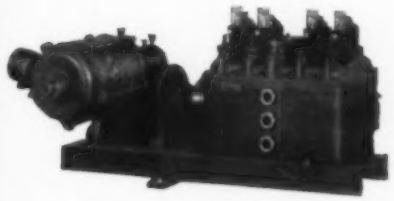
A. E. Penrose, formerly in production equipment section, Tulsa office, is promoted to regional salesman — production equipment for the Rocky Mountain region in Denver; F. R. DeWitt, former manager-sales development program, is store manager — supervisor for the Tulsa store area; and E. L. Jackson, salesman, Mt. Pleasant, Michigan, is assigned as salesman — supervisor at Mt. Pleasant.

A. M. Suitor is store manager at Drayton Valley, Alberta, Canada.

30,000 PSI?
yes- from
MANZEL

Manzel is the accepted source for lubricator requirements up to 30,000 psi. Your operations may not call for these pressures, but Manzel offers you the same outstanding dependability in its regular line of force feed lubricators. Experienced Manzel field engineers will work with you to solve any lubrication problem.

WRITE FOR COMPLETE CATALOG giving specifications and performance requirements to meet any of your lubricator needs.



Manzel

291 Babcock Street • Buffalo 10, New York

Specialists in lubricators and metering pumps since 1898

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NOW FOR THE FIRST TIME

NEW 385

INTERNATIONAL® UDT-817

Here's the all-new direct start 385 max. hp International UDT-817—a compact, heavy-duty 4-cycle, 6-cylinder engine thoroughly proven in six years of development and testing—backed by 26 years of experience in manufacturing and selling over 400,000 heavy-duty diesel engines.

Designed for versatile application in a wide variety of rugged oil field applications, the UDT-817 answers the demand for dependable high power and lower cost operation on compressors, pumps, and on drill rigs.

A wide variety of accessory equipment including air cleaners, flywheels for leading makes of torque converters and clutches, torque converter cooler, air control compressors, safety shut-offs, instruments and engine controls can be furnished to meet your installation requirements. Base, radiator, hood and dash, clutch and power take-off are available for complete power units.

For more specific information or application assistance, merely call your nearby International Power Unit Distributor or Dealer.

BRIEF SPECIFICATIONS

Type	4-cycle turbocharged
Bore and Stroke	5⅜ x 6″
Number of Cylinders	6
Displacement	817 cu. in.
Max. hp.	385 @ 2100 rpm
RATED HP	375 @ 2100 rpm
Max. Torque	1,040 lbs. ft. @ 1400 rpm
Compression Ratio	16:1
Weight	3,540 lb.
Lbs. per max. hp	9.2
Length, fan to flywheel	61½″
Height	56½″
Width	39½″
Flywheel housing SAE	No. 1

hp.
-817

FEATURES THAT PROVIDE DEPENDABLE, ECONOMICAL OIL FIELD POWER

- Fast direct starts with 24-volt electrical system.
- Direct injection of fuel under pressures to 20,000 psi by individual camshaft actuated multi-orifice injectors.
- Exclusive IH twin plunger metering pump directs equal and precise amounts of fuel to each injector in proper firing order according to load and speed demands.
- Turbocharger puts waste energy in exhaust gases to work for higher power output and lower fuel consumption.
- Dual intake and exhaust valves for free breathing efficiency.
- Positive valve rotators keep valve seats free of deposits.
- Aluminum alloy pistons working in replaceable wet cylinder sleeves with velocity swirl flow water cooling on outside, jet oil cooling on inside, for long life operating temperatures.
- Fully counterbalanced Tocco-hardened crankshaft with seven big main bearings and torsional vibration damper for smooth, dependable high power output.

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Trade Parade

National Constructors Association. W. R. Wood of Girdler Construction Division, Chemetron Corporation, was elected president. Donald W. Darnell, The Fluor Corporation Ltd., was elected vice president. New members of the executive committee are: R. L. Cashen, vice president, The H. K. Ferguson Company, Cleveland; W. Earl Dunn, vice president, Blaw-Knox Company, Pittsburgh; J. W. Smith, assistant vice president, The M. W. Kellogg Company, New York, and Darnell.

A. O. Smith Corporation. Archie C. Anderson was named technical director of the new reinforced plastics division. Dwight H. Davis was appointed controller and administrative assistant of the division.

Tyson Smith Company, division of Smith Industries. R. E. "Dick" Holmes, and Arthur M. Begley joined the engineering staff. Dan Parmlee joined as sales engineer for the Houston area, and J. E. "Johnny" Johnson, sales engineer, transferred from Houston to Corpus Christi, and will work in the Corpus-San Antonio-Southwest Texas area.

Other changes in the sales and service department are: J. H. "Jake" Nichols, formerly sales engineer in the Houston area, named assistant sales manager; Oscar Johnson, manager of the service department; W. F. "Bill" Dillenback, to sales engineer for Lafayette, Louisiana, and surrounding territory; and L. M. "Matt" Bracewell Jr., joined TYSCO as sales engineer for the Lafayette-New Orleans, area.

USI Robodyne, division of U.S. Industries, Inc. Edwin F. Shelley is elected president. He will retain his title and duties as director of advanced programs.

Cleco Air Tools, a division of Reed Roller Bit Company. S. L. Brown Jr, formerly assistant to the sales manager, has been named manager of general sales office. J. G. Hudson, former salesman, is now assistant to the sales manager. J. D. Browning has been named senior salesman of the Houston territory and L. E. Luthy, formerly with Remington Rand, has joined Cleco as a salesman in the Houston area.

Schlumberger Well Surveying Corporation. Willis P. Baker was appointed division sales manager for the Northeast division at Evansville, Indiana. He has served as a field engineer and district manager in the Illinois Basin.

U. S. Industries Inc. H. U. Garrett has resigned as vice president.

M. L. Mandeville has been named vice president and director of sales of the International division. He will organize and direct the sales program.

Globe Oil Tools Company. Gulf Coast division managers and their locations: McAllen, Texas — Charles C. Jones; Corpus Christi, Texas — Tom Latham; Houston, Texas — E. P. McDaniel; Beaumont, Texas — Bobbie McDaniel; Jennings, Louisiana & Lafayette, Louisiana — Sid Siadous; Houma, Louisiana & Venice, Louisiana — Jim Pierce; Brookhaven, Mississippi — H. J. Reynolds. L. D. Jones heads Globe's Gulf Coast operations.

The National Supply Company. Jack G. Howe was appointed plant representative for the Houston, Texas, plant. He has been engaged in wellhead sales work for the Corpus Christi district.

Philco Corporation. Phillip H. Goodwin, manager—military control systems; Charles L. Murphy, manager—radar systems, and George M. Rouzee, manager—advanced military systems, are new managers in government sales force, government and industrial division. Donald Kirk was named senior staff engineer—communications engineering.

Robertshaw-Fulton Controls Company. Robert R. Rosborough was named contract administrator at the aeronautical and instrument division. He was formerly proposal sales manager. W. J. (Jim) Chadburn was named manager of field operations, electronics of the same division.

Garrett Oil Tools. Robert J. Campbell and William T. Latham were named new sales engineers. Campbell will work in Southwest Louisiana district headquartered in Lafayette, and Latham, will work in the South Texas district, Corpus Christi.

T. R. Collins, serving as New Mexico district manager, will be manager of the newly-combined West Texas and New Mexico sales districts, with headquarters in Hobbs. The West Texas portion of the new district will still be handled through the Odessa office, with J. W. Staples in charge. W. K. Woodward, formerly West Texas district manager, is special sales engineer, concentrating on city sales in Garrett's Houston district. William K. Holleron transferred from Casper, Wyoming, to Houston, where he will be supervisor of sales for the firm's milling and coring operations.

D. W. Onan & Sons Inc. Edwin C. Swenson was promoted eastern regional sales manager. Arthur R. Johnson, named western regional sales manager, and Paul F. Richardson, promoted to manager, special products division.

United States Borax & Chemical Corporation. The Pacific Coast Borax Company division announced that Ralph Wall was named to the agricultural sales department in Jackson, Mississippi. He replaces J. M. Nunn, recently transferred to the Los Angeles office as a marketing specialist.

National Tube Division, U. S. Steel. Appointments of Louis W. Mason as sales manager — eastern area, and James G. Morrison as sales manager — central area were announced. Mason, who succeeds the late Andrew P. Happer, will make his headquarters in New York.

Morrison, who succeeds Mason as central sales manager, will be located in Chicago.

James P. Bacon is appointed manager —tubing specialties products; James H. Degnan is named manager — oil country tubular products; and George O. Nations becomes manager — standard pipe products.

American Steel and Wire Division, U. S. Steel. Clarence T. Gilchrist, area manager of sales-western area, has retired and B. M. Ashbaucher, for the past year manager of Chicago district sales succeeds him.

Appointment of **Brice James** as sales promotion assistant for the **Helipot Division of Beckman Instruments, Inc.,** has been announced. Prior to joining Beckman, James served as assistant advertising manager for G. M. Giannini & Company, Inc., Pasadena. **Forrest P. Dewey** has been appointed to the newly created post of manager of cost and accounting methods for Beckman.

Howard S. Kaltenborn, New York City industrial relations consultant, has been named vice president and assistant to president of the **Westinghouse Electric Corporation** and **Dr. S. W. Herwald,** manager of the Westinghouse air arm division at Baltimore, was elected vice president in charge of research. At the same time, Kaltenborn was elected a member of the board of directors of Westinghouse.

James Kelly has been appointed midwestern district manager for **Marsh Instrument Company** of Skokie, Illinois. **Mansur Storrs** has been appointed New England district manager. He will serve the states of Maine, Vermont, New Hampshire, Connecticut, Rhode Island, and Massachusetts. The Marsh Instrument office is in Quincy. **Don L. Warner** has been appointed district manager in the Philadelphia area. He will serve in eastern Pennsylvania, New Jersey, District of Columbia, Maryland, and Delaware. The new Marsh Instrument Company sales office in Philadelphia will also be under his direction.

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Books to Read

The Learning Process for Managers, *by Nathaniel Cantor. Published by Harper and Brothers, 49 East 33rd Street, New York 16, New York. Pages, 154. Price, $3.*

The author, who is professor of sociology at University of Buffalo, presents this book as an answer to what he feels is the largest problem of management training. He feels that the programs are carried out without clearly defined objectives and without full understanding of how true managerial direction is communicated. Although he feels the present movement in management development programs is encouraging, he describes the approach as a bandwagon fad. With expensive training directors and programs initiated before objectives are outlined, executives are caught up in a training without much understanding.

Cantor takes his theme from the Hoover Commission Report "The greatest weakness in the federal government's personnel is inexpert managerial direction." He also analyzes the structure of industry as a social institution and comes up with the proposition that leadership is greater self understanding. The importance of training is to develop a manager who can assist those directly associated with him in becoming more creative in their job performance.

Perspectives on Conservation, *by Henry Jarrett. Published by The Johns Hopkins Press, Homewood, Baltimore 18, Maryland. Pages, 260. Price, $5.*

Long range plans for development of a nation's resources nearly always sound spectacular and seldom are.

These essays on America's natural resources attract interest chiefly in the philosophical and political approach to conservation. The contributors are authorities. One points out the "lines and sinews of bureaucratic empires" that resist any streamlining of government regulatory bodies and mentions lack of standards measuring any results of public development of resources except politically.

Oil and gas resources are frequently discussed. Only expert in the industry who contributes is Minor S. Jameson, Jr., executive vice president of IPAA. His material is highly pertinent.

This work, published for "Resources for the Future, Inc." is necessary reading for thoughtful petroleum executives.

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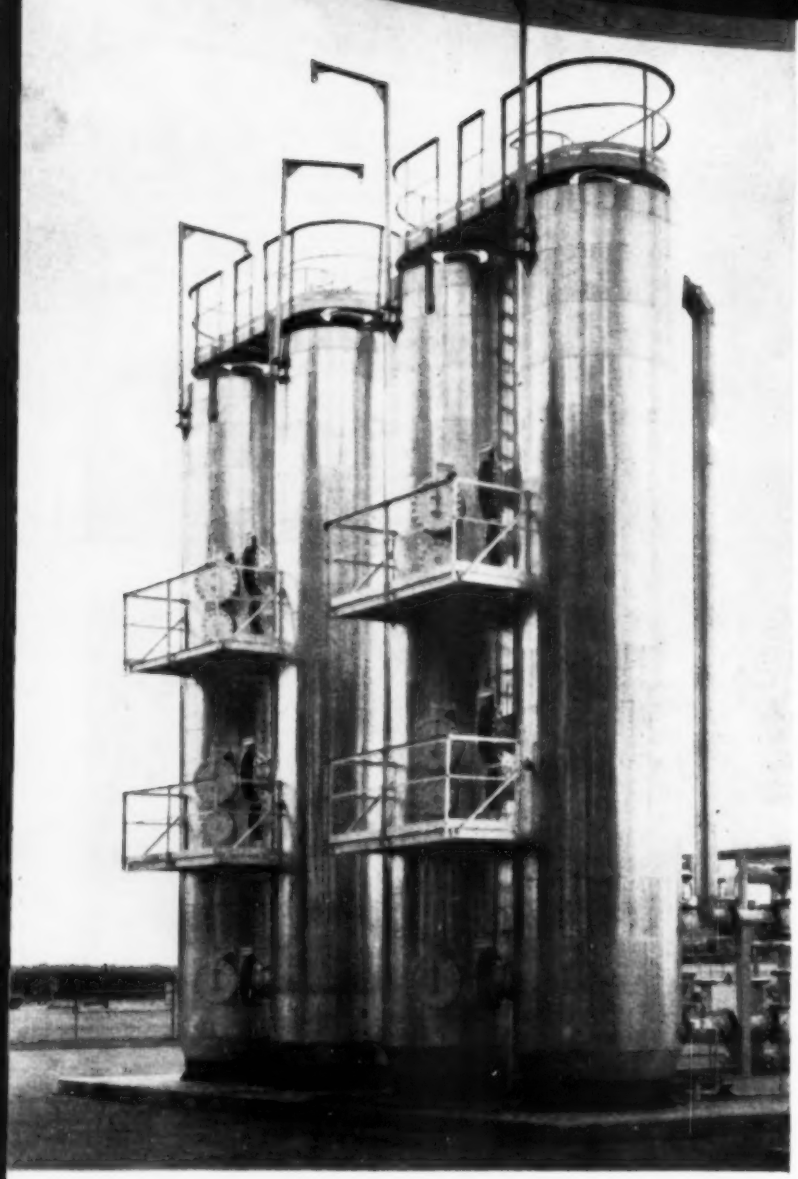

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Of Things To Come . . . In Oil

DECENTRALIZED ADMINISTRATION plans announced by two more major oil companies suggest new trends in industry management policy. Continental Oil, which introduced decentralization to its operations a few months ago, has been followed by Socony Mobil and more recently Sunray Mid-Continent. Sunray Mid-Continent will revamp its exploration and production divisions in the Rocky Mountain, Mid-Continent, West Texas, and Gulf Coast areas. Many oilmen will advance in status and responsibility in company ranks as a result. Socony Mobil's new plan revolves around "basic philosophy of centralized policy making and decentralized administration."

500,000 TO SEE INTERNATIONAL OIL EXPOSITION, host Tulsans are saying. Oklahomans are making final arrangements to accommodate that number during the oil show, scheduled May 14-23. Model drilling rigs and special company exhibit buildings are taking shape on the exhibition grounds. To make the most of the 10-day event, each day is being given a special designation — "Exploration Day," "Host Day," "Drilling Day," "Natural Gas Day," etc.

WATERFLOOD PLANS FOR ANETH FIELD are being considered by Four Corners area operators following a reservoir report that the southeastern Utah field would be a major oil producer for only 15 years — unless a program begins immediately. The study, made for the Utah Oil and Gas Conservation Commission by Core Laboratories, suggested that gas repressuring was not the answer for this type reservoir, and that even with an ample waterflood project, Aneth would produce only 235,000,000 bbl, or 28 percent of total reserve.

OKLAHOMA'S AND ARKANSAS' McALESTER BASIN will be the site of those states' next biggest play, predicts Don Busch, a Tulsa consultant. Busch foresees attractive farmouts for independents, based on recent discoveries in the Arkansas side of the basin, and increased activity as a result of new gas outlets. New leasing boom may be out of the picture, says Busch, since most leases in the eastern area were taken out two years ago — and still have eight years to go.

NATIONAL PETROLEUM COUNCIL, after a year of non-existence, will be effective in putting oil's best foot forward in 1959. Under the co-chairmanship of Walter Hallanan and Capt. M. V. Carson, NPC is expected to set style for similar groups representing other basic industries. After extensive "bargaining" with government groups, NPC is back in business with a government-appointed co-chairman for each committee, "doing things the way we've always done them," says one NPC member.

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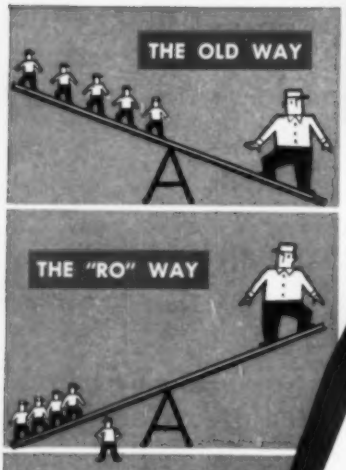
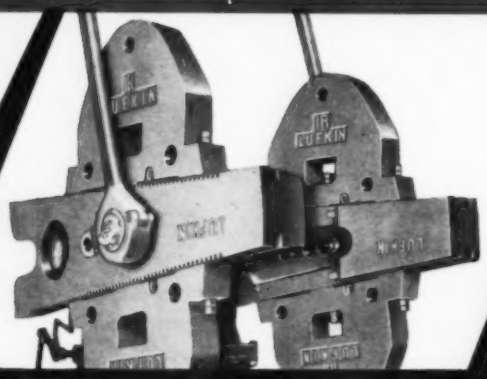
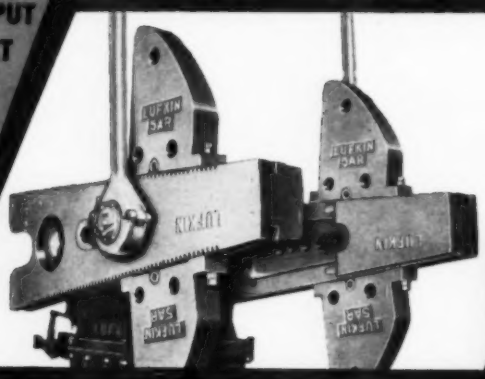


IT'S WHERE YOU PUT THE WEIGHT THAT GETS RESULTS.



Larger counterweights for above average requirements. Increased thickness at end of crank for extra counterbalance.



Smaller counterweights are interchangeable on the same cranks for reduced counterbalance requirements.

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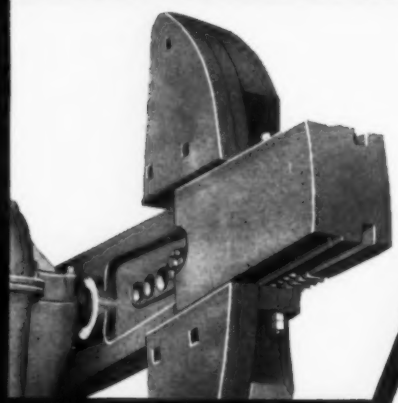

Extra space for thicker weights allows greater weight concentration at outer end of crank. Thick or thin auxiliary weights for greater counterbalance flexibility.

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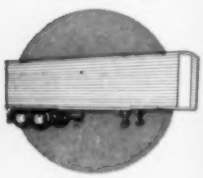

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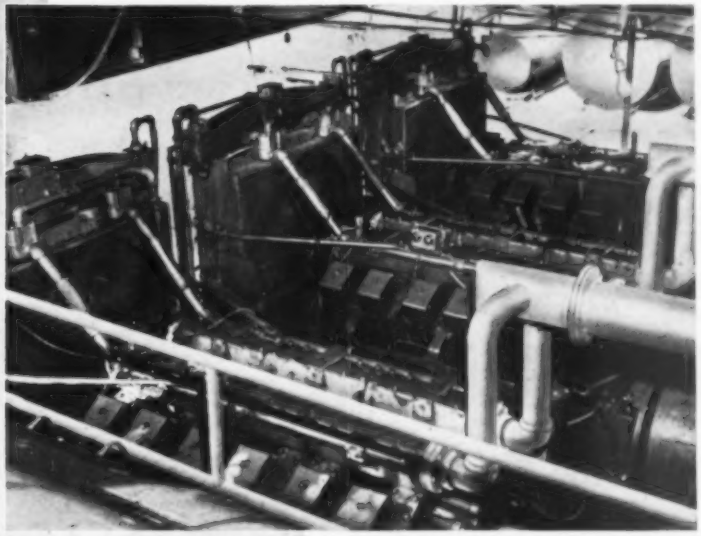

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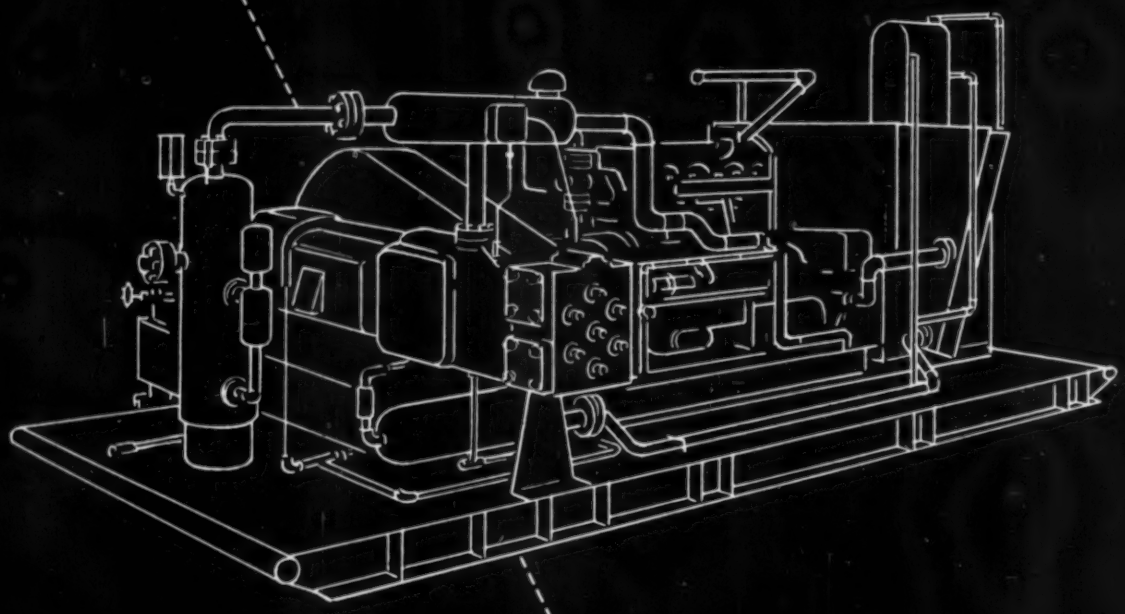

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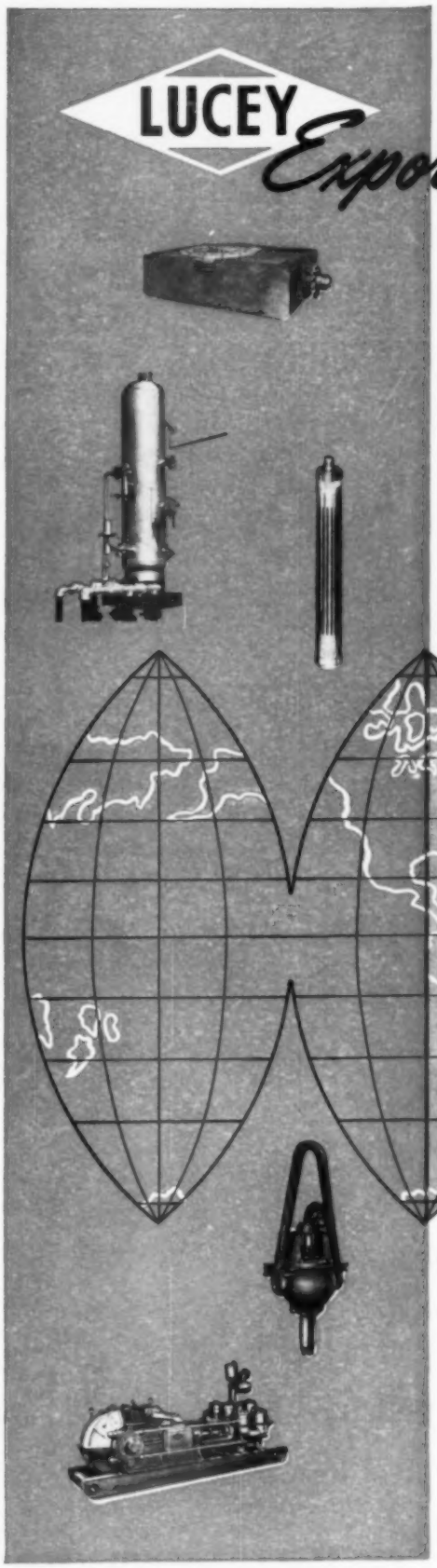

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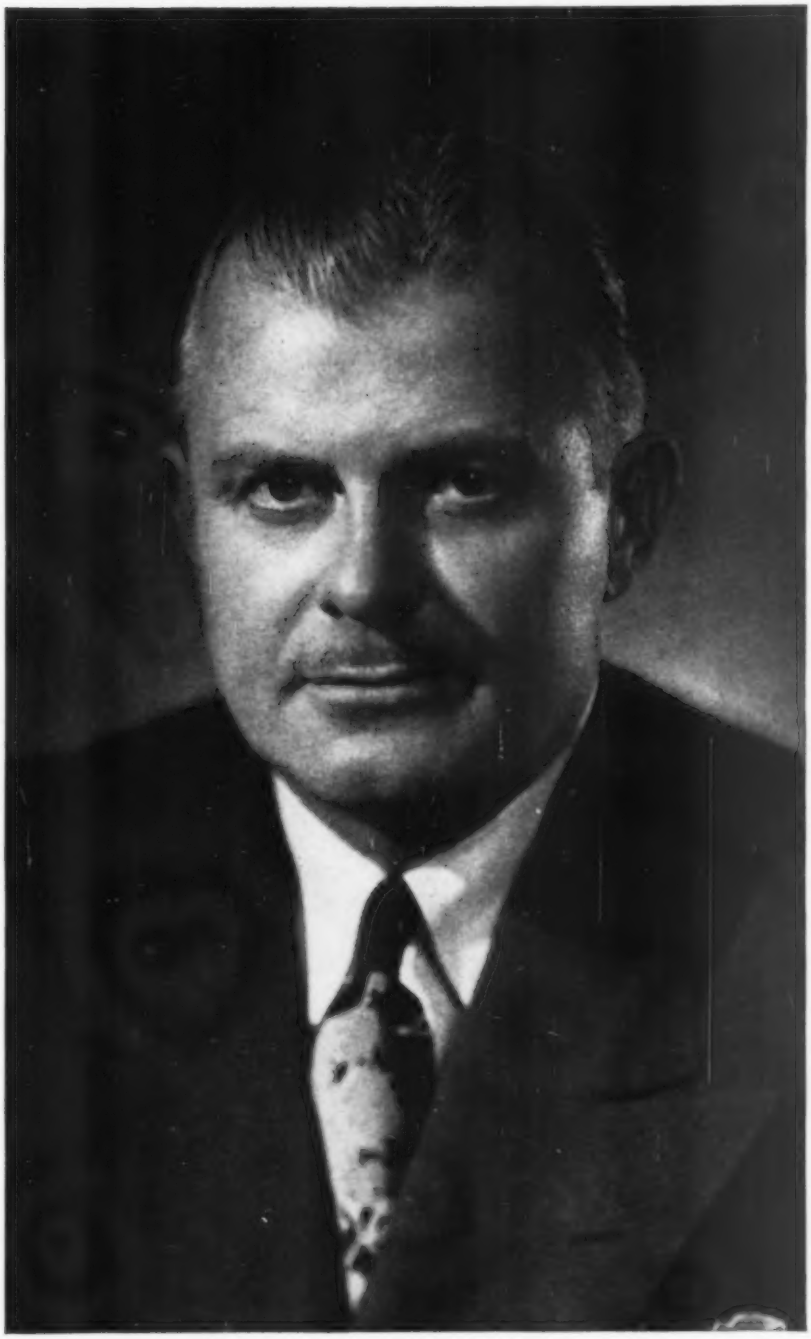

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At 360° F. Static BHT— slurries stay fluid with **Unaflo** Oil-Well Cement

On deep, high-pressure jobs, where an API Class F cement is needed, oilmen have learned to rely on Unaflo retarded oil-well cement. Fully compatible with other retarders, Unaflo cement helps make slurries pump easily, so that they follow the irregularities of well bore and pipe. Slurries stay fluid and pumpable under severe conditions of temperature and pressure, forming a strong, watertight, sulphate-resistant seal when set. Unaflo cement gives the dependable seal produced by a heavier and stronger slurry, plus the easy pumpability of a light, thin slurry. And its retarded set sustains high initial fluidity. It allows proper placement of cement, as well as an added margin of safety for delays or emergencies.

At varied depths and pressures, for cementing or recementing, for plug-backs or squeezes, Unaflo cement provides the **workable** slurry—one that pumps easily, sets hard. For more information, write Universal Atlas, 100 Park Avenue, New York 17, N. Y.

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DRILLING DATA

JOB: #2 Elue Roach—Gordon Drilling Co., Inc., Lake Charles, La., for Union Oil & Gas Corp. of La., Houston, Tex.

LOCATION: Lake Arthur Field, Jefferson Davis Parish, La.

DEPTH: 15,461 feet

TUBING-HEAD PRESSURE: 11,600 psi

DETAIL: 5" OD liner set from 13,992 feet to 15,224 feet; 326° F. Static BHT; cemented with 47 sacks Unaflo, 37 sacks (3,666 lb.) Barite, 50 lb. CMHEC (Diacel LWL) retarder. Composition gave slurry weight of 18 lb. per gal. 7" casing string tied into 7" liner at 10,113 feet (with BOT casing connecting sleeve) and cemented back to surface with composition of 1,600 sacks of Unaflo, 16,000 lb. Barite, 602 lb. of HR-4 retarder for slurry weight of 16.6 lb. per gal.

U-157

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Universal Atlas Cement Division of United States Steel

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BLACK MAGIC ?

GULFCO'S

TYPE RS-5 AUTOMATIC SLIP SEAL SUSPENSION

No hocus-pocus here! Certified laboratory tests by the Engineering Research Center of Lamar College of Technology, plus extensive field tests, prove that this newest member of the Gulfco family of well head equipment:

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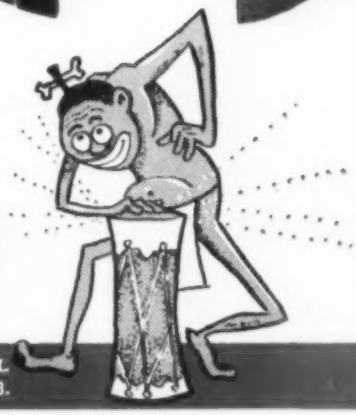
CLOSED POSITION

The RS-5 is one of five Gulfco suspension assemblies that are interchangeable in our RS & RS-F casing head bodies, providing a varied choice of casing suspensions and seals.

OPEN POSITION

Automatic! Interchangeable! Maximum Simplicity! Proven, Tested Performance! No wonder Gulfco beats the drums for the finest automatic slip seal suspension in the industry.



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First and only tool joints designed specifically for use on light weight drill pipe and tubing.
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Three years in designing, developing and in final field testing are behind this newest, most advanced WHELAND 16" PUMP. A folder giving the highlights of this new pump is yours for the asking . . . or we can give you current locations so you can see it in operation. You can't afford to buy any pump in this size until you've seen this new Wheland pump!

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Tuffy® Wire Rope Tips

Guard Against These Killers!

... Get The Full Measure of Service-Life Built In By Wire Rope Specialists

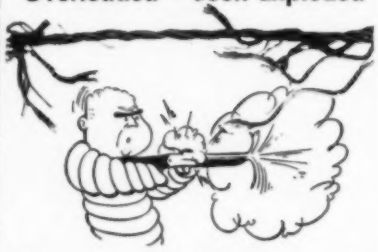
Mangled in a Wedge Socket

Here's a result of improper socketing. It was caused by using a poorly designed or worn-out wedge socket. Failure at the dead end can damage other sections of the rope, too.

Rusty Road to Ruin

Rust—No. 1 enemy of steel—takes a heavy toll in wire rope life. An insidious, silent type of killer, rust often does irreparable damage before it's even noticed. The one-strand break shown here resulted when the rope was allowed to become rust-bound through lack of lubrication. Tests show that, with other conditions ideal, properly lubricated rope has up to 10 times the life expectancy of dry rope.

Overloaded — Soon Exploded



The rated capacity of a wire rope is based on the breaking strength (catalog) divided by a safety factor applicable to the type of service or use. The grade of steel, type of construction and size of the rope determine tensile strength. It must be properly related to the loads it will carry, or costly and dangerous early failures are likely to occur.

Victim of the Bends

Excessive bending of wire rope accelerates wear. Generally, more flexible ropes are used as bending stresses increase (with decrease in tread diameter of sheave or drum). If a rope is operated on a sheave too small for its bending characteristics, early failure is certain. Through an exhaustive series of bending tests, Union Wire Rope engineers have compiled data that you can use to assure getting the rope construction that will give you the longest service life. Ask about it.

Tuffy Balanced Standard Rotary Line helped drill the world's deepest well—Wildcat I-EE in Pecos County, Texas. This rotary line is famous for top performance in use with standard rigs in any formation. It also does an outstanding job with jacknife rigs in deep drilling beyond 6000 feet.

Tuffy Balanced Jacknife Rotary Line: Made to the special needs of jacknife rigs drilling to 6000 ft. Has extra strength, with greater flexibility to move at higher speeds over the smaller sheaves and drums of jacknife rigs, and to give better reeving and spooling.

Tuffy Balanced Slings & Hoist Lines This team has made a name for cutting hoisting and downtime costs in all types of materials handling. Tuffy Hoist Line gives the balanced combination of strength and flexibility needed for a longer running rope. Tuffy Slings are made of an extra flexible, high-strength machine-braided fabric that smooths out uninjured after knotting or kinking.

FREE!

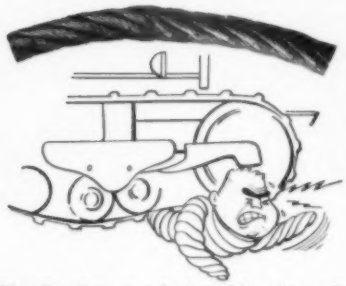
Complete handbook of wire rope use in oil field service

Latest, most complete information ever compiled on the subject in one publication. Shows the various rope constructions used by the oil industry, and gives full data tables on each. Includes (in their entirety) "A.P.I. Specifications for Wire Rope" and "A.P.I. Recommended Practice on Application, Care and Use of Wire Rope for Oil Field Service."

Write Union Wire Corporation, 2106 Manchester Ave., Kansas City 26, Mo. Specialists in high-carbon wire, wire rope, braided wire fabric and stress relieved wire and strand.

01

Crushed by a Tractor Cleat

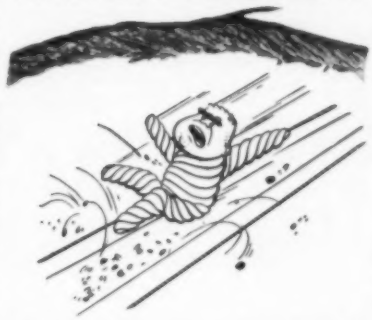


The Sunday punch for this piece of wire rope was delivered by a tractor cleat—just one of many crushing injuries caused by rope being run over or banged into by hard, sharp objects. Even the toughest wire rope is no match for this kind of mistreatment.

After a Suicide Jump

This rope jumped out of sheave and was soon destroyed by pulling around the shaft. Actually it was a case of sudden slack which threw the rope out of the sheave.

Burned on a Frozen Sheave



End of the line came quickly for this rope as the result of operating over a sheave that did not turn. Note the exceptionally heavy abrasion on one side of the rope. Sheaves should be checked thoroughly and often.

"Real Gone" From Beatings on the Drum

Even under normal operating conditions, drum wear gives wire rope severe punishment. This wear concentrates at the cross-over points and at the flange. Excessive drum crushing results from operating on small drums, excessive loading and poor winding. Smooth drums are not recommended. Here are typical "drum beatings": Cross-over wear; cross-over crushing on drum; drum crushing from poor winding; drum-crushing from small drum.

Although drum wear cannot be eliminated, its effects can be greatly reduced. Under properly engineered procedures, two and three times the service can be obtained from the same line by improving drum conditions. Union Wire Rope Engineers will help you with this problem. Get in touch with us for information.

On the "Blink" from a Kink

This open kink resulted from mishandling of rope. Guard against kinks by proper winding on the drum. Never pull a loop smaller. Always enlarge it, then straighten out the rope.

Strangled by a Misfit Sheave

When the bearing surface of a sheave is too small for the rope diameter, pinching action quickly destroys the rope — especially when it's overloaded. The victim shown here was knocked out in just 1½ hours of service.

Tuffy Wire Ropes are "Job Prescribed"—Each Designed for a Particular Type of Machine

There are thousands of wire rope constructions and Union Wire Rope specialists make them all. But, there is only one Tuffy line of wire ropes. Each Tuffy was developed and proved the one best rope for the particular work for which it is intended. It is designed as a functional part of the type of machine on which it is used.

Tuffy Wire Ropes are "job prescribed" and balanced in each prescription are all the ingredients of strength, flexibility and toughness to give you genuine relief from inefficient operation, foreshortened service life and safety hazards. You get longer service life and you cut down on your rope costs. Union Wire Rope Corporation, 2106 Manchester Avenue, Kansas City 26, Missouri.

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C1

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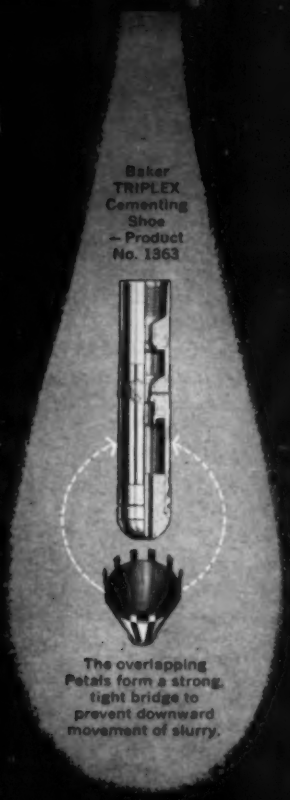
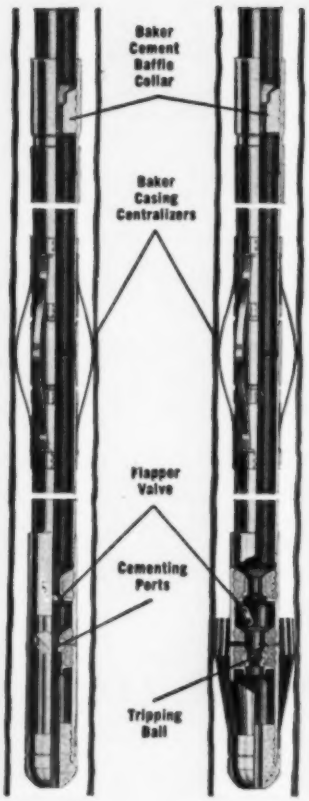
Protect permeable low pressure zones with the BAKER TRIPLEX cementing shoe...



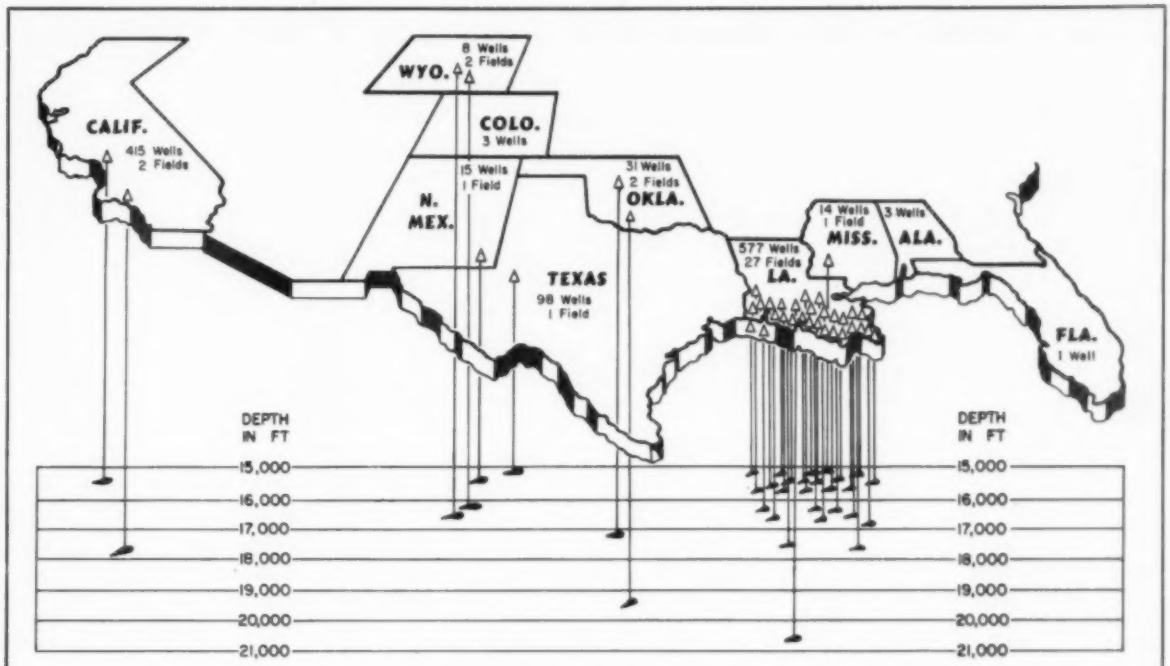


Cementing casing at a predetermined point above bottom, and at the same time protecting a lower, permeable zone from cement contamination always has been a difficult problem. Such work is now a routine operation with a Baker TRIPLEX Cementing Shoe.

A special float shoe is combined with a Baker Metal Petal Basket that expands to form a bridge and retain cement slurry above the Basket, even in large-diameter or irregularly shaped holes. The TRIPLEX Shoe, with its flapper-type back-pressure valve, operates as a conventional float shoe while landing the casing and conditioning the hole. When cementing is done and pump pressure is stopped, the valve closes and cement is held in place behind the casing until it sets.

Baker Casing Centralizers are installed on (and above) the shoe joint, thus providing a uniform annulus to receive the slurry. While running-in, a Hold-Down Strap (secured by shear screws) retains the Basket against the TRIPLEX Shoe, and the cementing ports are covered by the Tripping Valve. After reaching the desired point, a Tripping Ball is dropped to seat upon the Tripping Valve. Pressure is applied to shear the screws, force the Tripping Valve downward, and expose the cementing ports. This action releases the Hold-Down Strap and the Basket expands against the walls of the hole. When cementing starts, the slurry is directed upward by Baker "Whirling" Action, and retained above the shoe by the Metal Petal Basket.

BAKER OIL TOOLS, INC., HOUSTON • LOS ANGELES • NEW YORK



U. S. Deep Well Map. To date 35 fields in the U. S. have produced oil and/or gas from below 15,000 ft. Seven were added in 1958. Nine years before Standard of California's No. 5 Mushrush found the first oil at these depths. Now 7 states have deep fields with 119 producing wells. Louisiana has 27 fields with production from below 15,000 ft. Map shows number of deep wells and fields.

MORE DEEP HOLES AT LESS COST

Some 135 exploratory wells at super-depths found 26 new fields, 28 new pay zones and made 14 extensions to present fields . . . Costs were lower in 1958 but a well below 15,000 still costs an average of nearly $700,000

Ernestine Adams

"DRILL PIPE STUCK and could not be cleaned out. Hole was junked and well abandoned."

That is the final report of a deep drilling operation that cost considerably more than a million dollars. When you think of the preparation, the skill, and the money it takes to drill a wildcat three or four miles down you wonder why. Why does a company take a chance to the tune of a million dollars that oil is down there 15,000 to 20,000 ft beneath the surface?

The answer is being revealed in each deep drilling survey. The seige of deep reservoirs is yielding gradually to new methods and new equipment. Experience in deep drilling is gaining control over hazards of high temperature, high pressures, and massive weights.

The year 1958 went right on with deep drilling records — in depths and in quantity.

Phillips Petroleum Company No. 1-EE University reached total depth of 25,340 ft for a new record on May 26, 1958. This is in Pecos, Texas, and was completed in early 1959 as a dry hole. Shell completed a record Oklahoma dry test in October 1958. The No. 5 Rumberger in Beckham County went to 24,004 ft and is now the second deepest well.

At a time when drilling operations slowed about 10 percent for the year, deep drilling was keeping pace. In 1958 some 192 wells were drilled 15,000 ft and below. Our records last year showed 199 for 1957 but revisions this year brought the total down to 190 wells completed. Each year total completions are revised to take care of work-overs, redrilling in same hole, and sometimes changes in ownership before redrilling.

In Table 1 the steady growth of deep drilling is shown by years of deep well completions. Now total of wells below 15,000 is 795 with 489 (more than 61 percent) exploratory. This includes

Miss Adams is Management Editor.

TABLE 1. NUMBER OF WELLS COMPLETED 15,000 FT AND BELOW BY YEARS OF COMPLETION

Year	No. wells by date of completion	Exploratory	Producers	Average drilling time	Record drilling time	Average bits per well	Low bit record	Mud costs, average	Well costs, average	Average costs per ft	Total footage drilled	Ft/well average	Deepest well	Deepest producer
1938	1	1	1	—	284		195				15,004	—	15,004	13,175
1944	1	1	0	—	—	—	—	—	—	—	15,279	—	15,279	13,175
1945	3	3	0	490	—	222	—	—	—	—	63,480	15,870	16,655	13,175
1946	1	1	1	—	349	—	184	—	—	—	15,452	—	16,655	13,175
1947	8	8	1	267	121	181	73	$24,000	$570,000	$35.87	127,128	15,891	17,823	13,904
1948	7	6	2	328	113	303	99	28,000	551,000	34.34	112,329	16,047	17,823	14,255
1949	11	8	5	222	95	199	120	64,000	534,000	32.52	180,631	16,421	20,521	15,530
1950	5	2	3	235	150	181	106	63,000	577,000	36.72	78,565	15,713	20,521	15,530
1951	12	5	6	178	96	116	69	54,000	527,000	33.56	189,864	15,822	20,521	15,530
1952	25	17	9	212	83	138	44	66,000	549,000	34.77	396,850	15,874	20,521	16,102
1953	26	14	20	213	70	159	48	75,000	729,000	44.79	419,053	16,117	21,482	17,895
1954	58	30	31	182	71	117	40	92,000	651,000	40.87	923,879	15,929	21,482	17,895
1955	101	64	43	147	37	87	44	116,000	649,000	40.09	1,635,101	16,031	22,559	17,895
1956	154	77	78	150	36	89	31	122,000	683,000	42.18	2,494,062	15,988	22,559	20,745
1957	190	117	89	157	48	89	30	121,000	743,000	46.25	3,052,097	16,064	22,559	20,745
1958	192	135	100	130	34	79	24	107,000	692,000	43.18	3,075,648	16,019	25,340	20,745
Overall	795	489	389	160	34	98	24	$107,000	682,000	$42.37	12,794,422	16,094	22,559	20,754

field wells wildcatting below known reservoirs.

Deep Production

It is deep production that keeps operators drilling deep. Last year 135 wildcats and semi-wildcats discovered 26 new fields and 28 new pay sands, and made 14 extensions to present fields. This is a total of 68 new reservoirs. Out of 57 deep development wells, 32 were producers.

Seven fields were added to those producing below 15,000 ft, making 35 deep fields in all. (Table 2.) The additions include:

1. Leleux, Vermilion Parish, Louisiana, where Union Oil and Gas of Louisiana found 1100 Mcf per day gas in the Camerina sand at 15,554-612 ft.

TABLE 2. FIELDS WITH PRODUCTION 15,000 FT AND BELOW

First deep production*	Field	County or Parish	State	No. wells that produced below 15,000 ft	Deepest production ft
Richfield	North Coles Levee	Kern	California	1	17,895
Standard of Calif.	Wasco	Kern	California	1	15,530
Tidewater	Rayne Lane Well	Acadia	Louisiana	1	15,270
Union Producing	Deep Lake	Cameron	Louisiana	1	15,410
Humble O&R	Avery Island	Iberia	Louisiana	3	15,496
Shell	Weeks Island	Iberia & St. Mary	Louisiana	30	17,745
Texaco	Queen Bess Island	Jefferson	Louisiana	3	16,149
Union O&G of La.	Lake Arthur	Jefferson Davis	Louisiana	2	15,784
Caroline Hunt Sands	So. Thornwell	Jefferson Davis	Louisiana	2	15,398
Texaco	Bay de Chene	Lafourche & Jefferson	Louisiana	2	15,500
Gulf Oil	Timbalier Bay	Lafourche	Louisiana	1	15,730
Howell & Howell	St. John	Lafourche	Louisiana	2	15,210
John Mecom	Lake Washington	Plaquemines	Louisiana	7	20,745
Tidewater	Venice	Plaquemines	Louisiana	2	16,060
Pan American	Bastian Bay	Plaquemines	Louisiana	1	15,335
Sid Richardson Car.	Cade	St. Martin	Louisiana	1	15,085
Texaco	Cote Blanche Island	St. Mary	Louisiana	6	17,000
Humble O&R	Eugene Is. Blk 77	St. Mary (Offshore)	Louisiana	1	15,885
Superior Oil	Bayou Rambio	Terrebonne	Louisiana	2	15,034
Union Oil of Calif.	Caillou Island	Terrebonne	Louisiana	4	16,116
Pan American-Hunt	Block 39 SS	Terrebonne (Offshore)	Louisiana	1	16,842
Texaco	Dog Lake	Terrebonne	Louisiana	2	15,879
Superior Oil	Four Isle	Terrebonne	Louisiana	4	16,908
Texaco	Lake Barre	Terrebonne	Louisiana	9	16,573
Sun Oil	Lake Pelto	Terrebonne	Louisiana	4	16,084
Placid	Lapeyrouse	Terrebonne	Louisiana	3	16,100
Sid Richardson	Abbeville	Vermilion	Louisiana	1	15,012
Union O&G of La.	Leleux	Vermilion	Louisiana	1	15,612
Sid Richardson Car.	Riceville	Vermilion	Louisiana	2	15,880
Gulf	Soso	Jasper	Mississippi	1	15,256
Continental	San Simon	Lea	New Mexico	1	15,025
British American	Carter-Knox	Grady & Stephens	Oklahoma	10	17,382
Gulf Oil	New Hope	McClain	Oklahoma	1	18,944
Phillips	Puckett-Ellenburger	Pecos	Texas	3	15,324
Pure	West Poison Spider	Natrona	Wyoming	2	16,102
Pure	Badwater	Natrona	Wyoming	1	16,477
TOTAL	35 Fields		7 States	119	20,745

Note: Wells completed as potential gas discoveries that can produce below 15,000 ft but are shut in are not listed.

*Not necessarily company that discovered field.

2. Caroline Hunt Sands discovered a gas-condensate field at 15,350-98 ft in South Thornwell area, Cameron Parish, Louisiana.

3. Pan American Petroleum Corporation found gas-condensate production in Bastian Bay, Plaquemines, Louisiana, at 15,314-35 ft.

4. Gulf discovered 15,256-ft pay in the Soso field area, Jasper, Mississippi. This well also found oil at 12,617 ft, and a dual oil completion was made.

5. At Riceville in Vermilion Parish, Sid Richardson Carbon Company found a gas-condensate field at 15,025-66 ft.

6. Texaco found deep — 16,573 ft —production at Lake Barre, in Terrebonne Parish, Louisiana.

7. Humble opened deep production offshore St. Mary Parish, Louisiana, at Eugene Island, Block 77.

Producing Depths

Some deep wells find production in shallow sands. In comparing producing depths in 1958 with 1957 it is the deep zones that increased most.

For instance, above 12,000 ft there are not a great many more producing wells than the year before. In the 12,000 to 17,000 ft zone, however, 81 out of 100 wells were added in 1958 to the accumulated totals up to then. In other words, 81 percent of new producers completed last year were in these deep zones.

Trends

The outstanding characteristic of deep producers is the growing number of dual completions. At least 12 deep development wells were completed in two sands and two wildcats made dual discoveries.

Another significant development is the increased use of sidetracks and directional drilling. Several operators drilled original hole and then drilled one to four sidetracks.

TABLE 3. PRODUCING DEPTHS OF DEEP WELLS

Producing depth, ft	No. producers	Producing depth, ft	No. producers
2- 3,000	2	12-13,000	46
4- 5,000	3	13-14,000	61
5- 6,000	2	14-15,000	82
6- 7,000	4	15-16,000	86
7- 8,000	6	16-17,000	24
8- 9,000	11	17-18,000	9
9-10,000	10	18-19,000	1
10-11,000	18	19-20,000	1
11-12,000	23	20,000 +	1
	TOTAL PRODUCERS		389

TABLE 4. RECORD DEPTHS BY YEAR

Record Drilling Depths

	TD, ft
1938—Continental KCL, A-2, Wasco field, Kern County, California	15,004
1944—Phillips No. 1 Ada Price, Pecos, Texas	15,279
1945—Standard of California KCL 20-13, So. Coles Levee, Kern, California	16,246
1945—Phillips No. 3 Schoeps, Brazos, Texas	16,655
1947—Pacific Western No. 1 National Royalties, Miramontes, Kern, California	16,668
1947—Superior Oil Weller 51-11, Caddo, Oklahoma	17,823
1949—Superior Oil Limoneira No. 1, Montalvo, Ventura, California	18,734
1949—Superior Oil Pacific Creek No. 1, Sublette County, Wyoming	20,521
1953—Ohio Oil KCL No. "A" 72-4, Kern County, California	21,482
1956—Richardson and Bass 1L St. Lse 2414, Plaquemines Parish, Louisiana	22,570
1958—Phillips No. 1-EE University, Pecos, Texas	25,340

Record Production Depths

	Production depth, ft
1938—Continental No. A-2 KCL, Wasco field, Kern County, California	13,175
1938—Fohs Oil No. 1 Buckley-Bourg, DeLarge field, Terrebonne Parish, Louisiana	13,266
1943—Union Producing and Fohs Oil No. 1 Fitzpatrick and Vizard, DeLarge field, Terrebonne Parish, Louisiana	13,490
1944—Union Producing and Fohs Oil No. 2 Buckley-Bourg, DeLarge field, Terrebonne Parish, Louisiana	13,503
1945—Shell Oil No. 1 Smith State Unit 1, Weeks Island field, Iberia Parish, Louisiana	13,520
1946—Shell Oil No. 2 Smith State Unit 1, Weeks Island field, Iberia Parish, Louisiana	13,778
1947—Shell Oil No. 3 Smith State Unit 1, Weeks Island field, Iberia Parish, Louisiana	13,888
1947—Texas Company No. 1 Lafourche Basin Levee, Jefferson, Louisiana	13,904
1948—Pure Oil Unit No. 1 West Poison Spider, Natrona, Wyoming	14,307
1948—Shell J. A. Smith A-1, Weeks Island field, Iberia, Louisiana	14,255
1949—Standard of California No. 5 Mushrush, Wasco, Kern County, California	15,530
1952—Pure Oil No. 3 West Poison Spider, Natrona, Wyoming	16,102
1953—Shell No. 1 Weeks Gall Unit 1, Weeks Island, Iberia, Louisiana	17,122
1953—Shell Gonsoulin-Minvielle, State Unit No. 2, Weeks Island field, Iberia, Louisiana	17,306
1953—Richfield Oil Coles Levee A67-29, Kern, California	17,895
1956—Richardson & Bass et al No. 1-L St. Lse 2414, Plaquemines Parish, Louisiana	21,465

Redrilling and workovers show considerable attraction for operators. You'll notice the unusual number of temporarily abandoned wells in Table 5. We continue to carry them because sometimes that's the last report but you might say deep old wells never die. They can turn into producers. In 1945 Phillips Petroleum completed the deepest well in the world, the No. 3 Schoeps, which was drilled to 16,655 ft. In 1958 Thomas W. Clay took over the well and discovered good gas production—15,700,000 cu ft a day — at 2266 ft. A happy ending to an old story.

Costs

Drilling costs dropped more than $50,000 per deep well in 1958 after an all-time high in 1957 of nearly three-quarters of a million.

Average per well was $692,000, slightly more than $43 a ft. Seven deep wells were drilled for $300,000 or less; 19 tests or 12 percent cost more than $1,000,000 each. The record deep Phillips well is not included in this year's cost figures and it obviously cost well over $1 million and could have been close to $3 million. Original drilling cost of the Richardson and Bass record deep well in Louisiana was estimated at more than $2½ million before it was reworked.

A more distinct cost difference between wildcats and field wells is beginning to emerge since the number per year passed the 100-mark. Field wells averaged about $662,000 in 1958 when wildcats cost an average of $716,000 each.

A total of $133 million was spent on super-deep wells. Last year was the first year since 1950 that total spending on deep wells did not top the previous year.

For the first time total expenditures for all 15,000-ft and below wells went past the half billion mark. Operators to date have spent $542 million on deep drilling.

Lower expenditures this year are in spite of higher material and labor costs. The savings can be attributed directly to improved methods — a better understanding of operational problems. In other words, experience is paying off.

Drilling Time

Average drilling time for deep wells in 1958 knocked 17 days off the former low record of 147 made in 1955. This year saw the lowest average in history —130 days per well. Single record is also lowest yet made — 34 days. This was time required to drill Shell Oil No. 2 Weeks-Gall in Weeks Island field, Iberia Parish, Louisiana.

Placid drilled one offshore well in 39 days and another in 40 days. Humble drilled a Terrebonne Parish well in 42 days. Only wildcat with low drilling time (under 50 days) was Sunray-

TABLE 5. LOCATION AND AVERAGES OF WELLS DRILLED 15,000 FT AND BELOW

State	Number wells 1958	Total 15,000 ft holes	Completed as producers	Drilling time average days	Low drilling time record	Average bits per well	Low bit record	Deepest hole	Mud costs, average	Well cost average
Alabama	0	3	0	225		186		15,729	$ 55,000	$511,000
California	4	45	12	182	44	154	56	21,482	84,000	627,000
Colorado	1	3	2	226	90	179	94	17,033	74,000	603,000
Florida	0	1	0		485		144	15,155		
Louisiana	155	577	310	128	34	72	24	22,570	107,000	662,000
Mississippi	6	14	4	245	105	152	76	20,450	76,000	601,000
New Mexico	4	15	10	327	222	238	172	17,555	124,000	914,000
Oklahoma	10	31	15	321	202	223	154	24,004	117,000	862,000
Texas	12	98	33	222	61	149	28	25,340	126,000	730,000
Wyoming	0	8	3	385	318	252	199	20,521	74,000	904,000
TOTALS	192	795	389	160	34	98	24	25,340	$107,000	$682,000

TABLE 6. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED 15,000 FT AND BELOW

1. TD, ft 2. Prod. depth(s)	1. Company 2. Well	Drilled by	1. Field or area 2. County/Parish	1. Completed 2. Spudded	Mud program	Perf. in prod. zones	1. Initial prod., gravity 2. Coke, tubing pressure	Remarks
				CALIFORNIA				
15,074 D&A	Tidewater Lloyd 185	Loffland Bros.	Ventura	10-29-58 11-23-57				WC.
15,117 D&A	Union of Calif. U-R-8 Fillmore A-1	Drlg. & Explor. Co.	Fillmore Ventura	3-19-58 1-10-58			none	WC.
15,285 D&A	Standard of Calif. Seepe I3	Sun Drlg. Co.	Fillmore Ventura	12-17-57 10-25-57			none	WC. Drilled below known horizon. No. 13-A directed upstructure to Spaulding zone.
15,739 8,240	Shell Oil KCL 15X-24	Rocky Mt. Drlg Co.	NW 10 Sec. Kern	10- 2-58 12-27-57	Low pH sodium base	8,118-240	47 b/d, 27 Mcf	WC. Disc. new field in Miocene sand (122')
				COLORADO				
15,000 P&A	Conoco Scorup Summerville Cattle 1	Mt. States Drlg. Co.	Paradox Valley Montrose	12-27-58 9-58			none	WC.
				LOUISIANA				
15,000 14,670	California Co. St. Lse. 2162 #3	Loffland Bros.	Simon Pass St. Martin	11- 3-58 8-19-58		14,636-70	225 b/d 52.9° 5500 Mcf 16/64" TP 4500#	FW.
15,000 D&A	H. S. Cole, Jr. Dupree 1	Loffland Bros.	Cameron	3-14-58 12- 8-57			none	WC.
15,000 D&A	Gulf Nat'l Audubon Soc. 1	Falcon-Seaboard	Intracoastal City Vermilion	4- 1-58 12- 9-57	9.5# min. to 15.5# max.		none	WC.
15,000 TA	Sun Oil Belle Isle Corp. 44	Co. tools	Belle Isle St. Mary	11-27-58 8-14-58	Lime-treated emulsion 16.0# max.		none	WC.
15,000 D&A	Tidewater Abercrombie 2	C. B. Webster	Bastian Bay Plaquemines	2-17-58 11-23-57	Nat'l & red to 9500'—lime-base to TD		none	WC. 67 bits.
15,000 13,910 13,080	Sun Oil Belle Isle 39	Co. tools	Belle Isle St. Mary	2-25-58 11-10-57	Lime-treated oil emulsion 17.3# max.	13,900-10 13,070-80	211 b/d 29.6° 80 Mcf 304 b/d 34.2° 319 Mcf 5/64" TP 2750# & 1350#	FW. Extended field in "P" (48') and "K" (25') sands. 55 bits. Dual comp.
15,000 14,324	Sun Oil Belle Isle 43	Co. tools	Belle Isle St. Mary	5-15-58 2-27-58	Lime oil emulsion 14.2# max.	14,320-24	308 b/d 38.7° 322 Mcf 5/64" TP 1800#	FW. Extended field in "P" (62') sand. 49 bits.
15,001 11,000	Union O&G, La. #1 C. J. Thibodeaux	Loffland Bros.	Branch Acadia	6- 2-58 2-10-58	Lime oil emulsion 15.0# to 11,500'-17.1# to TD	10,990-11,000	26 b/d 38.7° 2000 Mcf TP 5850#	FW. Extended field in "M" (15') sand. 55 bits.
15,002 14,018	Shell Oil OCS-0443 A-2	Loffland Bros.	Eugene Is. St. Mary	11-22-58 4-20-58	Red oil emulsion 10# to 11,969' Lime emulsion 16# to TD	14,018	288 b/d 53.3° 3690 Mcf 16/64" FP 4150#	FW. Disc. new sand "T" (133') to extend field. 46 bits. Offshore well bottomed 1/4 mile from surface location. Regarded deepest directional well. Protective casing cemented at 13,000' considered deepest.
15,005 14,768	Calif. Co.—Monterey O. G. LeBlanc 1	Penrod Drlg. Co.	Morse Acadia	12- 3-58 6-12-58		14,748-68	294 b/d 51.8° 5425 Mcf 5/64" TP 6250#	WC. Disc. gas field.
15,007 12,916	Tidewater Abercrombie B-1	C. B. Webster	Cyprien Bay Plaquemines	8-12-58 5-18-58	Nat. to 3025', red to 9334', lime-treated to TD	12,906-16	Undet. 48.9° 4557 Mcf 13/64"	FW. Extended field. Dual comp. in "N" (140' net) and "O" (60' net) sands. 49 bits.
15,009 D&A	Union of Calif. Jos. Comeaux 1	Nicklos Drlg. Co.	So. Bosco Lafayette	3-31-58 12-23-57	High pH lime-base oil emulsion		none	WC. Used 47 bits.
15,015 D&A	Anderson-Prichard OCS 0490-A-1	Deepwater Expl. Co.	Ship Shoal Terrebonne	5- 8-58 2-24-58	High pH lime-base oil emulsion		none	WC. Offshore. Used 28 bits.
15,016 14,840 13,098	Sun Oil St. Lse. 2620-7	Brewster-Bartle	Lake Pelto Terrebonne	10- 6-58 7- 5-58	Lime oil emulsion 15.7# max.	14,810-40 13,088-98	387 b/d 34.2° 604 Mcf 227 b/d 34.2° 203 Mcf X-31 & 7/64" P. 4175#-3500#	FW. Extension in "R" (96') and "G" (33') sands.
15,027 D&A	Austral Expl. La. Furs 1	John W. Mecom	Vermilion	4-18-58 8-26-57	See remarks		none	WC. Mud: T-8 and lime-base oil emulsion 12.4# max. to 12,000'-wt. increased to 15.8# in 3 sdtk. holes.
15,047 13,982	Union of Calif. St. Lse 3088-1	Dixie Drlg. Co	Timbalier Bay Lafourche	2- 6-58 9-23-57	High pH lime-base oil emulsion	13,976-82	151 b/d 32.5° 40 Mcf 8/64" TP 970#	WC. Extended field in H-1 (25') sand. 62 bits. Plugged back sdtk at 14,250'.
15,050 14,308	Humble O&R Petit Anse 42	Co. rig #24	Avery Is. Iberia	1- 6-58 4-19-57	Low solid alka. Tannate-CMC oil emul. 16.0# max.	14,294-308	301 b/d 34.3° 1/8" TP 2900#	FW. in Discorbis sand (197') Sdtk at 11,109', at 11,061', and 14,184'.
15,090 12,765	Union O&G La. Moise Touchet 1	Gordon Drlg. Co.	Rayne Acadia	5 -6-58 2 -3-58	Lime oil emulsion 15.5# to 11,506' 16.0# to TD	12,760-5	162 b/d 48.8° 3200 Mcf ch. adj. TP 6400# 1¼ tub.	FW. Extension in "N" sand (36'). 55 bits.
15,095 D&A	Shell Oil Williams, Inc. A-1	Co. tools	Mystic Bayou St. Martin	3-31-58 1-19-58	10.6# caustic-quebracho to 12,480' 16.5# lime to TD		none	Semi WC. 46 bits.
15,100 13,802	Pan American #1 Unit X-9	So'eastern Drlg. Co.	Bastian Bay Plaquemines	5-20-58 1-24-58		13,796-802	400 b/d 29° 8/64" TP 2300#	FW.
15,109 D&A	Humble O&R LL&E Co. N-10	Co. rig #20	La. Hermitage Plaquemines	2-18-58 10- 1-57	Low solid alka tannate-CMC 15.8# max.		none	FW. Two sdtk from deepest hole.
15,116 14,094	Union of Calif. #1 14,300' Sd. Un. 2	Nicklos Drlg. Co.	Houma Terrebonne	11-13-58 8- 6-58	High pH T-8 oil emulsion	14,084-94	90 b/d 41° 8340 Mcf 28/64" TP 3800	FW. extension in 14,300' sand (150'). Used 51 bits.

TABLE 6. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED 15,000 FT AND BELOW — (Continued)

1. TD, ft 2. Prod. depth(s)	1. Company 2. Well	Drilled by	1. Field or area 2. County/Parish	1. Completed 2. Spudded	Mud program	Perf. in prod. zones	1. Initial prod., gravity 2. Coke, tubing pressure	Remarks
			LOUISIANA — (Continued)					
15,118 12,564	Superior Oil St. Lse 3051-6	Co. tools	Lac Blanc Vermilion	5- 4-58 12-28-57	17.8/58/ 1.9 at 15,118′	12,556-64	149 b/d 42.3° 162 Mcf 7/64″ TP 2350#	FW. in #53 sand (21′). 69 bits.
15,138 13,554	Superior Oil La Terre Co. A-10	Bay Drlg. Co.	Bayou Penchant Terrebonne	11-11-58 8-31-58	17.7/78/ .9 at 15,138′	13,520-54	204 b/d 46° 3850 Mcf 22/64″ TP 1650#	FW. in #68 sand (86′). 39 bits.
15,150 14,916	Texaco Lake Barre Unit 37-3	Co. tools	Lake Barre Terrebonne	6- 6-58 4-28-58		14,906-16	160 b/d 45.4° 1450 Mcf S-31 ch. TP 4600#	FW.
15,162 D&A	Pano Tech. Expl. St. Lse 2443-1		Deep Lake Cameron	1- 7-58 7-20-57			none	WC.
15,164 D&A	Tidewater J. B. Fasterling 1	Rowan Drlg.Co.	Cyprien Bay Plaquemines	6-15-58 12-17-57	Red to 9300′ Lime oil emulsion TD. 18.2# max.		none	FW. Used 96 bits.
15,179 12,656	Humble O&R Co. Miami Corp. M-6	Co. rig #39	Bayou Carlin St. Mary	3-10-58 7-24-57	Gyp-Q-Broxin oil emulsion 15.7# max.	12,644-56	48 b/d 57° 2275 Mcf 1/8″ TP 4325#	Semi-WC. Disc. new sand, Miocene (30′), 3rd sdtk went to TD.
15,196 14,802	Union of Calif. St. Lse 3033-2	Gracey Hellums	E. La. Palourde Assumption	10- 5-58 6- 8-58	High pH T-8 oil emulsion	14,782-802	240 b/d 59° 5000 Mcf 1/4″ TP 4550#	FW. extension in Discorbis #3 sand (25′). Used 71 bits.
15,200 12,674 12,510	Humble #B-1 Lutcher-Moore Lbr. Co.	Co. rig #53	No. Gibson Terrebonne	8- 3-58 3-23-58	Low solid alka. Tannate-CMC 17.8# max.	12,664-74 12,504-10	353 b/d 42.9° 1022 Mcf 423 b/d 39.1° 470 Mcf 1/2″ TP 5200# and 4700#	WC. Dual oil disc. in B-1 (19′) and B-1-D (38′) sands.
15,218 10,666	Placid Oil Co. OCS-0475-1	Penrod Drlg. Co.	Eugene Is. St. Mary	8-16-58 6-30-58		10,644-66	346 b/d 40° 125 Mcf 16/64 TP 1800#	FW. Block 128 offshore. Used 28 bits. Drilled in 30 days.
15,225 15,066	Sid Richardson Car. Leo P. Bonin 1	Dillard-Waltermire	Riceville Vermilion	4-24-58 8-19-57	Lime Base 18#	15,025-66	102 b/d 56.8° 3400 Mcf 8/64″ TP 9900#	WC. Gas disc. in Marg. Texanna (86′ net). Used 102 bits.
15,053 D&A	Phillips Pet. Stovall A-1	Harry L. Edwards	Live Oak Vermilion	1- 7-58 8-28-57			none	WC.
15,250 12,579	Phillips Unit A-1	Co. rig #41	Bastian Bay Plaquemines	5- 9-58 8-30-57	Low lime Driscose emulsion		264 b/d 54.7° 2100 Mcf 247 b/d 45.0° 310 Mcf 16/64″-1/2″ 4100#-2500#	FW. extended "O" and "K" sands. Dual comp. Used 76 bits.
15,250 D&A	Tidewater D. Bergeron 1	Falcon-Seaboard	Church Point Acadia	2-21-58 10-11-57			none	FW.
15,269 14,435	Texaco St. Lse. 2986-4	Continental Marine	Caillou Is. Terrebonne	3-19-58 12- 5-57		14,408-35	99 b/d 53.2° 5113 Mcf S-39 ch. TP 5000#	FW.
15,299 14,712	Superior #5 LL&E-St. Unit 9	Co. tools	Four Isle Terrebonne	7- 1-58 3-29-58	14/57/1.5 at 15,299′	14,688-712	92 b/d 45.3° 4364 Mcf 15/64″ TP 2800#	FW. in #78 sand. (66′)
15,305 11,870	Pan American R. R. Lyon et al 1		S. Thornwell Jefferson Davis	3-18-58 6- 8-57		11,850-70	83 b/d 43.5° 3000 Mcf 1/2″ TP 7200#	FW.
15,310 11,026	Calif. Co. Lafayette Parish Sch. Bd. 4	Delta Drlg. Co.	So. Bosco Lafayette	3-18-58 8- 5-57		10,988-11,026	72 b/d 47.2° 4000 Mcf 11/16″ TP 4348#	FW. extension on south flank.
15,330 10,266	Tex. Gas & Gasoline Wallace Dupont 1		So. Rayne Acadia	12-27-58 8-29-58		10,258-66	210 b/d 32° 152 Mcf 8/64″ TP 1770#	FW. in Heterostegina formation.
15,335 14,349	Humble O&R LL&E R-8	Co. tools	Bayou Penchant Terrebonne	12- 9-58 7-26-58	Low solid alka tannate CMC oil emulsion	14,329-49	160 b/d 36.7° 708 Mcf 1/2″ TP 2300#	FW. disc. new miocene sand (50′).
15,338 14,758	W. T. Burton Ind. St. Lse. 3137-1		La. Palourde St. Mary	12- 8-58 7-30-57		14,745-58	102 b/d 55.2° 2400 Mcf 12/64″ TP 3800#	Semi-WC. Offset to St. Lse. 2833-1 gas disc. Comp. in 4th sidetrack.
15,341 P&A	Kerr-McGee & Midwest St. Lse. 3028-1	Kerr-McGee	Marsh Is. Iberia	12- 3-58 8-21-58	High pH lime base 15#		none	WC. Stuck drill pipe and magnet when trying to fish bit cores at TD.
15,342 D&A	Gulf Oil St. Lse. 3278-1	Rowan Drlg. Co.	La. Raccourci Terrebonne	12- 8-58 9-24-58	10.0# min. to 17.0# max.		none	WC.
15,344 15,261	Texaco Lake Barre 36-1		Lake Barre Terrebonne	12-31-58 11- 3-58		15,249-61	227 b/d 48.4° 1896 Mcf S-32 choke TP 4800#	FW.
15,365 13,590	Superior La. Terre 9-1	Bay Drlg. Co.	Bayou Penchant Terrebonne	8-30-58 5-31-58	17.8/76/.8 at TD	13,550-60 13,570-90	402 b/d 46.6° 7024 Mcf 18/64″ TP 5200#	FW. in No. 68 sand (87′) Used 39 bits.
15,380 14,932 13,678	Tidewater #1 USA-BLM Unit X-9-2	Falcon-Seaboard	Bastian Bay Plaquemines	10-17-58 6-26-58	Red to 9300′-lime oil emulsion TD. 14.5# max.	14,912-32 13,658-78	68 b/d 43.8° 5048 Mcf 111 b/d 46.4° 3184 Mcf 12/64″-12/64″ TP 5750#—4200#	DW. in X (55′) and R (37′) sands. Comp. as dual gas well. 58 bits.
15,382 13,706	Superior Oil La Terre Co. B-6	Bay Drlg. Co.	Bayou Penchant Terrebonne	6- 1-58 3- 9-58	17.5/81/.7 at TD	13,691-706	460 b/d 46.8° 5853 Mcf 16/64″ TP 7400#	FW. in No. 68 sand and (51′) Used 50 bits.
15,391 14,308	Texaco St. Lse. 1249-26	Seaway Drlg. Co.	Caillou Is. Terrebonne	3-20-58 11-29-57		14,314-30 14,282-308	183 b/d 48.4° 4680 Mcf S-40 ch. TP 5200#	WC. Offshore disc. gas field.
15,400 D&A	Gulf Oil Cecile C. Crawford 1	Delta Drlg. Co.	Morse Acadia	10-14-58 6-10-58	9.3# to 18.3#		none	WC. Used 55 bits.
15,400 13,793	Texaco 42 St. Lse 340 CB1		Cote Blanche St. Mary	11-29-58 8- 4-58		13,763-93	346 b/d 28.7° 299 Mcf 8/64″ TP 2000#	FW.
15,407 14,576	British-American Terrebonne Unit D-1	Delta Drlg. Co.	Ramos St. Mary	6-25-58 3-18-58	Lime oil emulsion	14,482-576	318 b/d 60° 830 Mcf 12/64″ TP 7500#	Semi-WC. Disc. new gas sand in (Miocene) 42 bits.
15,439 14,798	British-American Whitney Nat'l Bk 1	Loffland Bros.	Ramos St. Mary	6- 3-58 11-16-57	Lime oil emulsion	14,790-98	153 b/d 52.2° 4000 Mcf 22/64″ TP 9300#	Semi WC. Disc. new gas sand (Miocene). Offset to Ramos disc. (1957).
15,466 15,466	J. W. Mecom-Freeport LL&E-San Bois 4	Cron & Gracey	L. Washington Plaquemines	11-12-58 6-25-58	Lime oil emulsion 15#	14,982-15,466	96 b/d 34° 20/64″ No prem.-gas lift	FW. Extension. 68 bits.
15,495 D&A	British-American C. M. Thibodeaux 1	Loffland Bros.	Ramos area Assumption	11-21-58 8-18-58	Gyp oil emulsion		none	WC. 51 bits.
15,500 13,894	Gulf #35 St. Lse. PP-192	Producers Drlg. Co.	West Bay Plaquemines	11-29-58 9- 9-58	10.3# to 18.0#	13,888-94	565 b/d 34.8° 768 Mcf 1/64″ TP 7200#	Semi WC. disc. new offshore pool.

TABLE 6. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED 15,000 FT AND BELOW — (Continued)

1. TD, ft 2. Prod. depth(s)	1. Company 2. Well	Drilled by	1. Field or area 2. County/Parish	1. Completed 2. Spudded	Mud program	Perf. in prod. zones	1. Initial prod., gravity 2. Coke, tubing pressure	Remarks
			LOUISIANA — (Continued)					
15,509 D&A	Gulf Oil St. Lse. 2691-1	Brewster-Bartle	E. Leeville Lafourche	6-17-58 3-13-58	9.8# to 15.9#		none	WC. 61 bits.
15,500 D&A	Shoreline Drlg. Emil Kuntz et al 1	Co. tools	N. Turtle Bayou Terrebonne	10- 2-58 6-29-58	Gyp base 17.4# max.		none	WC. 40 bits.
15,501 P&A	Pan American Paul Herpin 1		Leleux Vermilion	6- 9-58 3- 3-58			none	WC.
15,505 P&A	Texas Gulf Prod. LL&E 1	Penrod Drlg. Co.	Terrebonne	9- 6-58 6-17-58			none	WC. 57 bits.
15,510 D&A	J. P. Owen Leger Unit 1	Co. tools	S. E. Rayne Acadia	7-23-58 4- 7-58			none	FC. 47 bits.
15,510 15,054	Pan-American Lacassine Co. B-1	Harry L. Edwards Drlg.	S. Thornwell Jefferson Davis	2- 6-58 8- 3-57		15,044-54	100 b/d 45.2° 3000 Mcf $^{8}/_{64}$" TP 7750#	Semi WC. Disc. new gas pay.
15,520 14,433	Trunkline Gas-Cyprus Oil Jos. Stansbury 1	C. B. Webster	Grosse Isle Vermilion	12-15-58 7- 7-58		14,415-18 14,422-33	272 b/d 47.8° 4271 Mcf $^{5}/_{8}$" TP 8575#	WC. Oil disc.
15,530 D&A	Shell Continental Ld. & Fur. E-4	Co. tools	N. Turtle Bayou Terrebonne	12- 1-58 9- 7-58	11.5# caustic-quebracho to 11,042', 15.5# Lime to 12,801', 18.0# lime TD		none	Semi WC. on east flank. 35 bits incl. 2 dia.
15,546 D&A	Texas Gulf Prod. St. Lse. 3194-1	Rowan Drlg. Co.	Terrebonne	4-30-58 2- 6-58			none	WC. Used 49 bits.
15,549 14,522	Howell & Howell Caldwell Sugars 1	Co. tools.	St. John Lafourche	6-16-58 1-14-58	Lime oil emulsion	14,484-522	282 b/d 46.1° 4082 Mcf $^{16}/_{64}$" TP 4420#	Semi WC. Extended field in Operc. 3. 47 bits.
15,570 D&A	Lone Star Prod.— Gulf States 3	Circle Drlg	Raceland Lafourche	8-10-58 1-15-58	Lime base 13.8# to 17.5# 12,036 to TD		none	FW. 50 bits.
15,583 D&A	Delhi-Taylor-Conoco St. Lse. 3133-1	Continental Shelf Drlg.	Point au Fer Terrebonne	7-27-58 12-27-57	High visc. low water loss, lime base		none	WC.
15,595 J&A	Miss. River Fuel-Hope Nat. Gas LL&E F-1	Rowan Drlg. Co.	Terrebonne	11- 4-58 6-14-58			none	WC.
15,600 14,329 13,470	Texaco St. Lse. 1249-29	Co. tools	Caillou Is. Terrebonne	3-31-58 12-27-57		14,308-29 13,464-70	281 b/d 36.8° 349 Mcf 194 b/d 34.1° 148 Mcf S-31 & S-31 TP 2575# & 1625#	FW. Dual oil comp.
15,600 15,080	Texaco Lake Barre 26-6		Lake Barre Terrebonne	12-12-58 8-27-58		15,056-80	210 b/d 42.8° 1040 Mcf S-29 ck. TP 4450#	FW.
15,606 D&A	Conoco (St. Lse. 983) OCS 0146-A-4	Shoreline Drlg. Co.	West Delta Plaquemines	4- 9-58 1- 1-58			none	FW. Offshore in Block 58.
15,630 D&A	Calif. Co. Continental Ld. & Fur 1	Rowan Drlg. Co.	Terrebonne	10- 8-58 6-24-58			none	WC.
15,673 D&A	Sid Richardson Car.-Tidewater U-B-1	Falcon-Seaboard	Cade St. Martin	2-11-58 8-27-57	Lime base		none	WC. Used 90 bits.
15,696 15,482 15,380	Texaco Lake Barre Unit 26-4	Co. tools	Lake Barre Terrebonne	6- 5-58 3- 1-58		15,472-82 15,360-80	168 b/d 27.5° 321 Mcf 228 b/d 26.1° S-26 & S-31 ck. TP 3550# & 2150#	FW. Dual comp.
15,700 15,989 15,058	Texaco Lake Barre 26-3	Co. tools	Lake Barre Terrebonne	2-17-58 11- 6-57		15,551-89 15,024-58	211 b/d 26.4° 150 Mcf 312 b/d 25.3° 357 Mcf S-28 & S-31 ck. TP 2350# & 2900#	FW. Dual comp.
15,738 D&A	Sun Oil Co. Miami Corp 1	Co. tools	Bell Isle St. Mary	8- 1-58 5-16-58	Lime treated oil emulsion. 15.2# max.		none	Semi-WC. on east flank. 39 bits.
15,751 15,398	Caroline Hunt Sands Lacassine Co. 2	Penrod Drlg. Co.	S. Thornwell Cameron	8-30-58 1- 8-58	Weighted lime oil emulsion	15,350-98	88 b/d 44.2° 2200 Mcf $^{8}/_{64}$" TP 7600#	WC. Disc. new field in Camerine sand. 77 bits.
15,799 15,388	Shell Oil Co. J. T. Caffery et al 7	Co. tools	Cote Blanche St. Mary	10-30-58 2-15-58	11.3# salt-satur. to 12,496'-13.6 to 16.1# oil base TD.	15,326-72 15,388-410	271 b/d 48.8° 1827 Mcf $^{12}/_{64}$" TP 3859#	FW. in "Q" sand (87') extended field. 43 days fishing stuck drill pipe at 13,417', 15,519 & 15,756'. 90 bits.
15,800 15,320	Humble O&R Petit Anse Co. 43	Co. rig #24	Avery Island Iberia	9- 4-58 12-29-57	Low solid alka. Tannate-CMC oil emulsion 14.7# max.	Not perf.	Gas	FW. in Discorbis (35'). Sidetracked at 13,082' after reaching 15,167'.
15,800	Placid Oil Co. Marie S. Wurzlow	Penrod Drlg. Co.	Terrebonne	12-15-58 10-11-58				WC. New field.
15,800 10,445	Sinclair O&G A. F. Hargrove U 1-1	Falcon-Seaboard	Vermilion	9-13-58 6-22-58		10,440-5	64 b/d 46.3° 3315 Mcf $^{16}/_{64}$" TP 7200#	Semi WC. Confirmation well of new field. Disc. new gas sand.
15,846 15,648	Shell Oil Co. Weeks Gall 2	Co. rig	Weeks Island Iberia	12-29-58 11-16-58	Low pH red 10.5# max	15,630-6 15,642-8	244 b/d 35.2° 1668 Mcf $^{16}/_{64}$" TP 3950#	FW. in "V_2" sand (25'). Drilled in 34 days.
15,883 J&A	Miss. River Fuel-Hope Nat. Gas LL&E 1	Miss. River Fuel rig	Terrebonne	10-28-58 7-31-58			none	WC. Unable to recover stuck drill pipe at 15,833'. J&A.
15,890 14,924	Texaco St. Lse. 1249-36	Co. tools	Caillou Is. Terrebonne	11- 2-58 8- 5-58		14,919-24	160 b/d 45.4° 1518 Mcf $^{11}/_{64}$" TP 1450#	WC. Disc. oil sand.
15,900 P&A	Union O&G of La. Mrs. F. Lyons 1	Gordon Drlg. Co.	Lake Arthur Jefferson Davis	6-25-58 2-10-58	Lime base oil emulsion 15.0# to 10,600' to 18.0# TD.		none	FW. 83 bits.
15,902 P&A	Pan American Hebert Helms & Co. 1		Cameron	4-11-58 10-25-57			none	WC.
15,911 P&A	Magnolia Pet. Sweet Lake Ld. & O B-4	Co. tools	Chalkley Cameron	11-13-58 6-23-58	Native mud to 6500'-oil emulsion TD. Gyp-Q-Broxin-DMS to log		none	WC. West extension of Chalkley. 49 bits.

TABLE 6. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED 15,000 FT AND BELOW — (Continued)

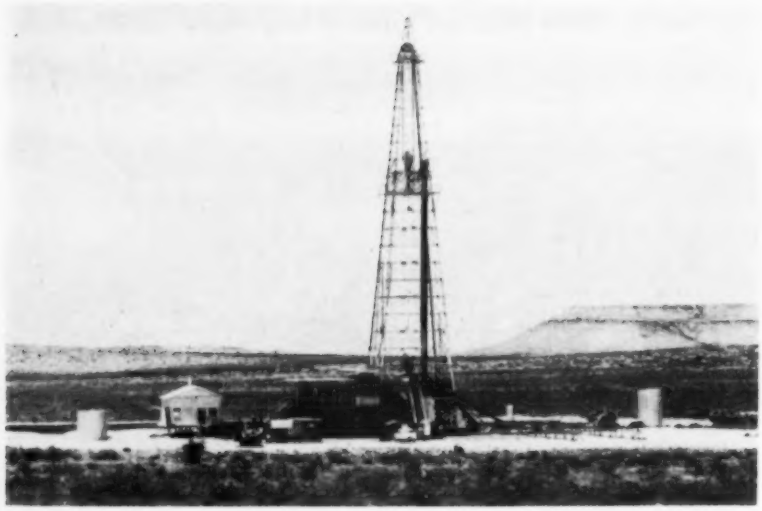
1. TD, ft 2. Prod. depth(s)	1. Company 2. Well	Drilled by	1. Field or area 2. County/Parish	1. Completed 2. Spudded	Mud program	Perf. in prod. zones	1. Initial prod., gravity 2. Coke, tubing pressure	Remarks
			LOUISIANA — (Continued)					
15,918 15,885	Humble O&R OCS-0425-A-2	Hawkins & Wilkins	Eugene Is. St. Mary	4- 3-58 8-11-57	Gyp-Q- Broxin oil emulsion 14.0# max.	15,865-85	60 b/d 44.8° 9900 Mcf $^{22}/_{64}$" TP 5300#	Semi-WC. Offshore disc. New gas pay in Miocene sand (133').
15,918 D&A	Shell Oil Co. LL&E 1	Co. tools	Terrebonne	12- 5-58 8-31-58	12# low pH caustic-quebracho to 14,415' 14# low pH gyp-Q-Broxin TD		none	WC. Used 53 bits.
15,924 15,630	Placid Oil et al L. Lapeyrouse 1	Penrod Drlg. Co.	Lapeyrouse Terrebonne	8-21-58 6- 7-58		15,608-30	143 b/d 53.2° 4600 Mcf $^{16}/_{64}$" TP 4900#	Semi-WC. Disc. new gas pay. 59 bits.
15,959 15,048 13,256	Sun Oil Co. St. Lse. 2620-5	Brewster-Bartle	Lake Pelto Terrebonne	6-24-58 3- 2-58	Lime treated oil emulsion 15.8# max.	15,036-48 13,242-56	446 b/d 32.6° 536 Mcf 228 b/d 33.6° 167 Mcf $^{8}/_{64}$"-$^{14}/_{64}$" TP 3800# and 1975#	Semi-WC. Extended field in "O" (66') and "H" (77') sands 75 bits. Dual comp.
15,972 15,850	Texaco Lake Barre Unit 38-3	Co. tools	Lake Barre Terrebonne	8-20-58 6- 7-58		15,845-50	233 b/d 46° 2759 Mcf S-35 ck. TP 5750#	FW.
15,980 D&A	Shell #1 Lake Charles Naval Stores	Bankhead Drlg. Co.	Newton Calcasieu	3-19-58 12-15-57	10# red to 8000' 10-16# lime plus 10% oil TD		none	WC. 43 bits.
15,999 TA	Texaco Dog Lake Unit 2-3		Dog Lake Terrebonne	11-11-58 5-27-58			none	FW. Stuck drill pipe TD
16,000 14,964	Pan American St. Lse. 3258-1	Co. tools	Lake Raccouri Lafourche	11-14-58 8- 9-58		14,908-22 14,954-64	332 b/d 48.7°5,200 Mcf $^{16}/_{64}$" TP 5000#	WC. New gas disc.
16,000 D&A	Sinclair O&G Co. Harry Bourg 1	Crown Rigs Inc.	Terrebonne	12-10-58 9-15-58			none	WC. 4 mi. NE Bayou Bambo Fld.
16,001 10,026	Continental Oil OCS-0134-E-1	Shoreline Drlg Co.	Grand Isle Jefferson	6-21-58 11-19-57		10,020-6	188 b/d 32.5° 153 Mcf $^{8}/_{64}$" TP 1600#	FW. Offshore Blk. 47. Comp. in KA Miocene gas 7' oil 15'
16,005 D&A	British American Avoca, Inc. 1	Delta Drlg. Co.	S. Ramos St. Mary	12-22-58 9- 2-58	Lime oil emulsion		none	WC. Used 45 bits.
16,021 D&A	Hunt Oil-Pan Am. LL&E 2	Penrod Drlg. Co.	Triumph Plaquemines	1-21-58 10-15-57	Weighted lime oil emulsion		none	WC. Drilled in 63 days.
16,021 TA	Shell Oil Co. H. LeBoeuf 1	Grady Roper	Cossinade Vermilion	8-11-58 5- 7-58	10.4# red to 9200' to 17.4# lime to TD		none	WC. Drill pipe stuck at 16,021'.
16,039 TA	Texaco Dog Lake Unit 3-1		Dog Lake Terrebonne	2-11-58 8-22-57				FW. 3-hr. test at 15,516-32' showed 216 b/d oil-6606 Mcf/d gas.
16,040 D&A	Placid-Pan Am. St. Lse. 2857-4	Penrod Drlg. Co.	Caillou Is. Terrebonne	4-13-58 1-28-58			none	Semi-WC. Drilling time, 40 days. 54 bits.
16,040 9,920 8,091	Pure Oil Co. OCS-0204-1	Kerr-McGee	Block 39 Vermilion	6-16-58 2- 9-58	18.3# 8% oil emulsion T-8 (shale control)	9,906-20 8,049-77 8,085-91	65 b/d 48° 5120 Mcf 28 b/d 48° 3766 Mcf $^{14}/_{64}$" & $^{14}/_{64}$" TP 3525# & 2547#	FW. Dual comp. Offshore. Used 53 bits.
16,054	Continental Oil Clemile Savoy	Dillard-Waltermire	M. Milton Lafayette	8- 5-58				WC. Hole lost at 16,054'. Setting whipetock at 12,200'.
16,063 P&A	Hassie Hunt Trust St. Lse. 2964-1	Penrod Drlg. Co.	N. Belle Isle St. Mary	7-29-58 3-26-58	Weighted lime oil emulsion		none	WC.
16,094 P&A	Pan American LL&E B-2		Bastian Bay Plaquemines	6- 5-58 12-17-57			none	WC. 3 sidetrack holes.
16,098 TA	Texaco Erath Unit 38-7	H. E. T. Drlg. Co.	Erath Vermilion	4-13-58 10-14-57			none	FW. Stuck drill pipe
16,100 13,283	Texaco St. Lse. 340-ECBB-15		Bayou Sale St. Mary	12-25-58 6-15-58		13,264-83	225 b/d 30.8° 74 Mcf $^{10}/_{64}$" TP 625#	FW. 900' west of #2 well.
16,155 TA	Tidewater Oil Lacassine 1	Clegg & Hunt	Lacassine Vermilion	11- 1-58 6- 4-58	High lime oil emulsion		none	WC. Severe mud kick drilling at 16,155' Drill pipe stuck. Hole junked.
16,160 D&A	Placid Oil Co. OCS-0477-1	Penrod Drlg. Co.	Eugene Is. St. Mary	7- 3-58 5- 8-58			none	WC. Offshore. Drilled in 51 days. Used 24 bits.
16,244 D&A	Blk. 27 Assoc. Ltd. OCS-0226-A	Coastal Marine Drlg.	S. Timbalier Lafourche	7-21-58 5- 7-58			none	WC. Offshore in S. Timbalier Blk. 27. 3 series perf above 4160'.
16,250 P&A	Hassie Hunt Trust Nole Broussard 1	Penrod Drlg. Co.	Le Roy Vermilion	7-10-58 6- 1-58			none	WC. Redrill. Previously aban. by Crown Central at 14,676'.
16,299 14,610	Union of Calif. LL&E 3090-1	Gracey Hellums	Caillou Is. Terrebonne	2- 5-58 10-10-57	High pH lime oil emulsion	14,600-10	87 b/d 57.1° 1379 Mcf $^{13}/_{64}$" TP 1520#	WC. Disc. new sand in Robulus (10').
16,300 TA	Sun Oil Co. St. Lse. 2620-4	Brewster-Bartle	Lake Pelto Terrebonne	2-16-58 9-11-57	Lime base oil emulsion 14.9# max.			FW.
16,321 D&A	Howell & Howell St. Lse. 2656-1	Penrod Drlg. Co.	Bayou Boullion St. Martin	4-24-58 1-18-58	lime base oil emulsion		none	WC.
16,386 13,495 13,360	Union of Calif. St. Lse. 2826-15	Gracey-Hellums	Caillou Is. Terrebonne	11-13-58 7-19-58	High pH T-8 oil emulsion	13,486-95 13,350-60	258 b/d 32.2° 276 Mcf 186 b/d 33.6° 172 Mcf $^{5}/_{64}$",$^{5}/_{64}$"TP 2700#&2450#	Semi-WC. extended field in Timbalier Bay sand 17 (17') and sand 16 (20') Dual comp. with 2 strings 2" tubing. 53 bits.
16,445 D&A	Wm. T. Burton Ind. Cooke & Goodrich-1	Co. tools	St. Martin	9-14-58 5-24-58			none	WC.
16,455 D&A	Hassie Hunt Trust Noah Prejean 1	Penrod Drlg. Co.	Leroy Area Vermilion	5-27-58 3-13-58	Weighted lime oil emulsion		none	WC. Used 47 bits.
16,466 15,376	Superior Oil Co. R. W. Buckley et al 2	Co. tools	Four Isle Terrebonne	11-26-58 7-18-58	14/58/.8 at 16,466'	15,366-76	246 b/d 50.5° 6593 Mcf $^{18}/_{64}$" TP 4050#	FW. in No. 81 sand (77') 54 bits.
16,485 D&A	J. W. Mecom- Freeport Oil LL&E 2	John W. Mecom	L. Washington Plaquemines	2- 4-58 10-12-57			none	FW. Redrilled 1956 well. P&A at 16,218'

TABLE 6. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED 15,000 FT AND BELOW — (Continued)

1. TD, ft 2. Prod. depth(s)	1. Company 2. Well	Drilled by	1. Field or area 2. County/Parish	1. Completed 2. Spudded	Mud program	Perf. in prod. zones	1. Initial prod., gravity 2. Coke, tubing pressure	Remarks
LOUISIANA — (Continued)								
16,487 16,060	Tidewater Oil Co. Cattle Farms Inc. A-1	Rowan Drlg Co.	Venice Plaquemines	1-22-58 7-25-57	Nat. to 3025'-red-later high pH lime	16,018-60	181 b/d 44.6° 1217 Mcf $^{20}/_{64}$" TP 2950#	Semi-WC. New oil pay in M-24 sand (118') Used 100 bits.
16,500 9,676	Shell Oil Co. Sweet Lake Ld. Oil 6	Circle Drlg. Co.	Chalkley Cameron	11-19-58 5-12-58	#10 red to 8200' 10# to 17.5# lime 10% oil to TD	9,360-4 9,639-76	105 b/d 55° 4690 Mcf $^{20}/_{64}$" TP 2700#	Semi-WC. Extended field in "W" sand (16') Used 41 bits.
16,509 16,009	Texaco Lake Barre 28-2	Co. tools	Lake Barre Terrebonne	11-16-58 6- 8-58		16,002-9	291 b/d 45.3° 3754 Mcf S-28 ck. TP 5500#	FW.
16,553 D&A	Pan American St. Lse. 3291-1		W. Leeville Lafourche	7-22-58 4- 6-58			none	WC.
16,638 TA	Texaco Lake Barre 13-1	Co. tools	Lake Barre Terrebonne	3-21-58 10- 8-57			none	WC.
16,653 D&A	Sid Richardson Car. Blanche Mauhoules 1	Co. tools	Riceville Vermilion	10-16-58 5- 5-58	Lime base 18#		none	WC.
16,717 10,978	Superior Oil Co. Rockefeller St. Lse. 2038-24	Co. tools	Deep Lake Cameron	4-18-58 6-18-56	17.1/58/1.9 at 16,703'	10,972-8	86 b/d 51° 4844 Mcf $^{16}/_{64}$" TP 3800#	FW. No. 40 sand (18') TA 12-18-56 to 7-8-57. Used 111 bits.
16,866 TA	Gulf Oil Corp. St. Lse 1772-48	Rowan Drlg. Co.	Timbalier Lafourche	1-25-58 5-12-57	10.2# to 17.3# max.		none	Semi-WC. 132 bits.
16,910 16,832	J. W. Mecom LL&E 2-K	Mecom & Richardson & Bass	L. Washington Plaquemines	12-18-58 9-25-57		16,788-832	178 b/d 39.3° $^{5}/_{64}$" TP 1850#	Semi-WC. Disc. new oil pay. Used 132 bits.
16,965 D&A	Sun Oil Co. Waterford A-1	Co. tools	Lirette E. Terrebonne	3- 8-58 12-24-57	Lime treated oil emulsion 17.0# max.		none	WC. Used 39 bits.
16,973 15,612	Union O&G of La. Thurbert Duhon 1	Loffland Bros.	Leleux Vermilion	7-23-58 2-27-58	Lime base oil emulsion 15.5# to 11,500' to 18.1# TD	15,554-612	5 b/d 39.4° 1100 Mcf $^{12}/_{64}$" TP 7300	WC. Disc. new field in Camerina sand (14'). 50 bits.
17,000 14,530	Humble O&R Co. LL&E N-11	Co. rig #20	L. Hermitage Plaquemines	5- 7-58 2-19-58 7 -58	Low solid alka tan-nate CMC oil emulsion 15.9# max.	14,516-30	no gage	Semi-WC. Disc. new sand in Miocene (16').
17,000 15,374	Shell Oil Co J. T. Caffery et al 6	Co. tools	Cote Blanche St. Mary	1-11-58 7- 9-57	12# salt satur. to 14,082 16# oil base to TD.	15,364-74	32 b/d 21.2° 152 Mcf $^{8}/_{64}$" TP 2500#	Semi-WC. Disc. new sand "Q" (80').
17,000 13,895	Sunray-Skelly-Buffalo St. Lse. 3020-1	Crown Drlg. Co.	Live Oak Vermilion	2-17-58 6-25-57	Oil emulsion	13,891-5	15 b/d 48.6° 1950 Mcf $^{16}/_{64}$" TP 3950#	WC. Disc. gas field in Mid-Miocene (14'). Used 134 bits. Drld. in 45da.
17,000 D&A	Texaco St. Lse. 340-WCBB-92	Norton Drlg. Co.	Cote Blanche St. Mary	5- 9-58 7-17-57			none	WC.
17,000 TA	Texaco St. Lse. 2856-2		Caillou Is. Terrebonne	1-20-58 10- 7-57			none	FW.
17,057 13,178	Atlantic Ref. Co. Frank A. Godchaux 7	Atlas Drlg Co.	Live Oak Vermilion	5- 7-58 12- 2-57	Gyp oil emulsion	13,172-8	112 b/d 48° 5210 Mcf $^{11}/_{64}$" TP 8700#	WC. Disc. new sand-Frank sand (30'). 54 bits.
17,057 15,335	Pan American St. Lse. 3008-1		Bastian Bay Plaquemines	1-15-58 7-23-57		15,314-35	60 b/d 51.4° 786 Mcf $^{5}/_{64}$" TP 5600#	WC. Disc. new sand.
17,150 P&A	Texaco Parish Lands 14		Horseshoe B. St. Mary	1-18-58 7- 5-57			none	WC. Stuck drill pipe. P&A.
17,187 16,375	Superior Oil Co. Parish Sch. Bd. 1	Co. tools	Four Isle Terrebonne	7-16-58 1-19-58	15.6/63/.9 at 17,187'	16,355-75	358 b/d 47.9° 3167 Mcf $^{15}/_{64}$" TP 3990#	Semi-WC. Disc. new sand. 58 bits.
17,420 16,100	Placid Oil et al LL&E St. Lse. B-6	Penrod Drlg Co.	Lapeyrouse Terrebonne	9-16-58 5-21-58		16,084-100	104 b/d 51.4° 5227 Mcf $^{19}/_{64}$" TP 5750	Semi-WC. Disc. new gas pay.
17,500 D&A	Tenn. Gas Trans. Co. Morgan Plantation 2	Chance Drlg. Co.	Lake Arthur Jefferson Davis	11-1-58 4-18-58			none	WC. on SE flank of W. Lake Arthur. Had oil and gas shows.
17,500 14,112	Placid Oil Co. et al St. LL&E Gas Un. 5-B	Penrod Drlg. Co.	Lapeyrouse Terrebonne	1-14-58 8- 5-57		14,100-12	97 b/d 41.4° 4215 Mcf $^{12}/_{64}$" TP 4100	FW.
17,517 13,153	Shell Oil Co. Contin. Ld. & Fur E-2	Co. tools	Turtle Bayou Terrebonne	6- 2-58 1- 2-58	12# caustic quebracho to 11,355'-16# lime to 14,255' 18.6# lime to TD.	13,143-53	41 b/d 51.6° 4400 Mcf $^{11}/_{64}$" TP 5845#	Semi-WC. Confirm well disc. New gas pay in Miocene (60'). Orig. hole to 16,853', PB 16,175' and sidetracked to TD.
17,655 D&A	Conoco-Delhi-Taylor St. Lse. 3260-1	Stewart & Douger	Philo Brice Lafourche	8-28-58 3-14-58			none	WC. Two sidetracks.
18,000 P&A	Pan American St. Lse 3134-1	Clegg & Hunt	Terrebonne	2-23-58 10-16-57			none	WC. 3 mi. NW Pointe Au Fer field.
18,105 15,880	Sid Richardson Mrs. N. H. Broussard 1	Co. tools	Riceville Vermilion	12- 7-58 4-30-58	Lime base 17.9# max.	15,812-16 15,865-80	85 b/d 57.9° 1460 Mcf $^{5}/_{64}$" TP 4267#	semi-WC. New gas pay in Lower Cyclammine (23' net).
18,155 TA	J. W. Mecom-Freeport E. Cockrell, Jr. 87	Co. tools	L. Washington Plaquemines	11-12-58 2-17-58	17.5# lime base oil emulsion		none	FW. Attempt to extend field. 178 bits.
18,487 16,213	Texaco St. Lse. 3064-1	Co. tools	Lake Barre Terrebonne	4- 6-58 8-30-57		16,204-13	182 b/d 25.8° 195 Mcf $^{5}/_{6}$" TP 1650	WC. Extended field to SE.
18,638 14,921	Texaco-TXL Oil St. Lse. 3065-1	Noble Drlg. Co.	Caillou Is. Terrebonne	6-18-58 9-10-57		14,918-21	242 b/d 36° 226 Mcf S-31 ck. TP 2200#	WC. east of Caillou Island field. Disc. new sand.
18,898 D&A	E. C. Cockrell, Jr. St. Lse 2647-2	Circle Drlg. Co.	Six Mile L. St. Mary	4-11-58 7-23-57	Gyp 18.5#/0.5 CC wh. at TD		none	WC. 251 days drilling. Stuck drill pipe at 17,790'.
MISSISSIPPI								
15,323 D&A	Sinclair Solomon Gore 1	Jett Drlg. Co.	Jones	10-30-58 5- 8-58			none	WC.
15,939 9,644	Skelly-Kin-Ark Oil Joe Pittman 1	Gulf Coast Drlg. & Expl.	Dexter Walthall	6-30-58 12-21-57		9,640-44	124.15 b/d 33° $^{5}/_{6}$" TP 700#	WC. New pay & first oil production in Dexter field.

TABLE 6. DESCRIPTION OF WELLS IN THE UNITED STATES DRILLED 15,000 FT AND BELOW — (Continued)

1. TD, ft 2. Prod. depth(s)	1. Company 2. Well	Drilled by	1. Field or area 2. County/Parish	1. Completed 2. Spudded	Mud program	Perf. in prod. zones	1. Initial prod., gravity 2. Coke, tubing pressure	Remarks
			MISSISSIPPI — (Continued)					
16,372 D&A	Sinclair Robinson L&L 1		Green	1-18-58 7-14-57		none		WC.
16,602 D&A	Humble T. R. Sistrunk 1	M. R. Young Drlg. Co.	Lawrence	7- 5-58 7- 4-57	Low solid alka.-tan. max. 10.9#	none		WC.
16,616 D&A	Calif. Co. Calco 1 Bd. Suprv. 3	M. R. Young Drlg. Co.	Mallalieu Lincoln	7-12-58 12-21-57		none		WC.
19,037 12,617 15,256	Gulf Soso Tract 28-7 #1-ZB	Zach Brooks Drlg Co.	Soso Jasper	5-13-58 9-28-57	Fresh water clay 9# to 12#	12,617 & 15,256	316 b/d 39.5°+ 153 b/d 33° $^{15}/_{64}$" TP1570# & 3075#	WC. New sand. Dual comp. in Houston & Cotton Valley sands.
			NEW MEXICO					
15,000 8,514	Sinclair St. Lse 1-403	A.W. Thompson, Inc.	Lea	4-24-58 10- 8-57		8,504-14	478 b/d 34° $^{24}/_{64}$" TP 100#	WC. Disc. new field.
16,100 14,454	Continental Bell Lake UN. 5-M	Carl B. King Drlg. Co.	Bell Lake Lea	11- 4-58 2- 7-58		14,417-54	7400 Mcf 1" ch. TP 6603	Semi WC. Disc. new sand.
16,600 12,916	Texaco Richards 1	Parker Drlg Co.	Lea	1-20-58 11-29-56		12,909-16	48 b/d 60° 1794 Mcf $^{18}/_{64}$" TP 1681	WC. Gas condensate disc.
17,555 12,929	Shell James Ranch 1	Parker Drlg Co.	Eddy	3- 1-58 11-30-57		12,920-29	104 b/d 7500 Mcf $^{8}/_{64}$" — $^{32}/_{64}$"	WC. Gas condensate disc. Atoka sand.
			OKLAHOMA					
15,807 15,540	British-American Bell	Falcon-Seabrd Drlg. Co.	Knox-Bromide Grady	12- 7-58 4-26-58	Lime oil emulsion	15,317-540	600 b/d 52.6° 4300 Mcf TP 5842#	Semi WC. Extended field. 2nd and 3rd Bromide. 179 bits.
15,826 15,753	Gulf Oil McKinney 1	Parker Drlg. Co.	Carter-Knox Stephens	4-20-08 7- 1-57	Fresh water, oil emulsion.	15,753 134 ft sd.	560 b/d 50.8° 5550 Mcf $^{1}/_{2}$" FTP 1380#	WC. Extended field in Bromide. 174 bits.
15,848 10,208	Lone Star Prod. Co W. C. Bolling A-1	Big Chief Drlg. Co.	Garvin	10-10-58 8-15-57		10,065-208	17 b/d	WC. Disc. new field.
16,682 T.A.	British-American English 1	Dick Wegener	Carter-Knox Grady	2-21-58 7- 2-57	Lime oil emulsion	none		FW. Temp aban. May be used as facility well. 184 bits.
16,820 P&A	British-American Hayes C-1	Viersen & Cochran	Knox-Bromide Grady	3- 8-58 8-14-57	T-8	none		FW. 182 bits.
16,953 D&A	Pan American Harrison 1	Helmerich & Payne	Carter-Knox Grady	2-21-58 6-28-57		none		FC.
16,980 15,665	British-American Teter 1	Big Chief Drlg Co.	Carter-Knox Grady	3-30-58 3- 1-57	T-8	15,172-665	591 b/d 53° 4220 Mcf $^{11}/_{64}$" TP 5800#	Semi WC. Extended field. 2nd and 3rd Bromide. 275 bits. Well blew out 10,816'. Burned rig.
17,004 D&A	Pan American Mitchell Unit 1	Big Chief Drlg. Co.	Carter-Knox Grady	12-31-57 3- 2-57			none	Semi WC.
24,004 D&A	Shell Oil Rumberger 5	Helmerich & Payne	Beckham	10-19-58 7-13-57			none	WC. Deepest well comp. in 1958. Now 2nd deepest in world.
			TEXAS					
15,000	Texas Eastern Trans. E. W. Craig 1 & Henck 1	Grey Wolf Drlg. Co.	Galveston				none	WC.
15,000 TA	Union of Calif. Houston Farms Dev. 1	Meadows & Walker	S. E. Danbury Brazoria	10-11-58 1-28-58	High pH lime oil emulsion.		none	WC. Temp aban. 39 bits.
15,000 D&A	Texaco Tocker Gas Unit O/A-1	Continental Marine Exp.	Arcadia Galveston	1-14-58 9- 7-57			none	WC.
15,099 11,472	Hunt Oil #52 Elsinore Royalty	Penrod Drlg. Co.	Pecos	10-28-58 9-11-57			4100 Mcf	WC. New gas disc.
15,155 D&A	Phillips O'Daniel 2	Co. tools #31	Alta Loma S Galveston	10-20-58 8-19-58	Low lime. Drisc. emulsion.		none	FW. Lost hole due to blowout. 28 bits.
15,358 8,752	Humble #91 Galves. Bay St. A	Co. rig #31	Red Fish Reef Chambers	9-14-58 4- 2-58	Gyp-Q-Broxin 17.6# max.	8,748-52	122 b/d 38° 156 Mcf $^{1}/_{2}$" TP 855#	Semi WC. Dry as WC. Comp. in field pay, Basal Frio.
15,556 12,446	Magnolia #1 Brown-Bassett	Co. rig #7	Brown-Bassett Terrell	3- 2-58 5-15-57	Lime base surfactant mud alternating with gas	12,387-446	75,000 Mcf $^{21}/_{64}$" SIP 5011	WC. New gas disc. in Silurian (thickness 65') 101 bits.
16,139 D&A	Max Pray R. D. Mills 1	Falcon-Seaboard	Wheeler	8-22-58 1-19-58			none	WC.
16,655 2,266	Thos. W. Clay Schoeps 1	Lu-Tex Drlg. Co.	Brazos	Reworked 6-24-58		2,261-66	15,700 Mcf TP 934#	WC. Gas disc. Orig. drilled to TD by Phillips in 1945 as #3 Schoeps, then deepest well in world.
17,320 8,280	Union Prod. Co. St. Tract 348-1	C. G. Glasscock	Laguna Madre Kenedy	12-23-58 7-18-58		8,275-80	7250 Mcf RP 3184#	WC.
19,020 14,670	Phillips #1 Harral A	Co. tools Rig #25	So. Hi Tunis Pecos	11-21-58 5-22-57	Low lime. Driscose emulsion.	14,580-670	53,000 Mcf	WC. New gas disc. in Wolfcamp. 193 bits.
19,503 D&A	Ginther, Warren & Co. A. O. Killam 1	Dillard & Waltermire	Webb	9-30-58 12-14-57	Phos. to 7000'. Sod. surfactant 19.5# max. to TD		none	WC. 92 bits. Blowout.



World's Deepest Well. View of Phillips No. 1-EE University in Pecos County, Texas. It is 25,340 ft or 4.8 miles deep. (See Page B-121.)

Skelly-Buffalo Vermilion Parish well that made a gas discovery. It was drilled in 45 days.

Only one well — a Grady County, Oklahoma producer — required more than a year to drill to TD.

The new low drilling time in California was made by Union Oil of California in the Fillmore field. It required only 44 days to drill to TD 15,117 ft, the shortest time outside Louisiana. On the same well, however, a sidetrack from 10,000 ft to 14,104 ft took another 23 days before the well was abandoned.

Bits Used

A significant drop in number of bits per well was made in 1958 and a new low record for one hole. Average per well was 79 bits compared to 89 in 1957 and to 87 in 1955, the previous low.

Three wells used less than 30 bits. Placid Oil Company's No. 1 OCS-0477, Offshore St. Mary Parish, Louisiana, used a record low of 24 bits. The same company used 28 bits in another offshore well. Only 28 bits were used by Phillips Petroleum in a Galveston County, Texas, well and by Anderson-Prichard in an offshore Terrebonne Parish, Louisiana, well.

The range in 1958 went from 24 to 264 bits for one well. Three wells required more than 200 bits — one in Lea County and one in Eddy County, New Mexico, and one in Grady County, Oklahoma.

Mud Programs

Since many companies give a brief statement on their mud programs, the variety can be seen in Table 6, where these are given.

Costs have gone down from $121,000 average in 1957 to $107,000 last year. Field wells show lower mud costs than exploratory wells. The average for development wells is $85,000 with a range of $17,300 to $210,000 for mud. Drilling mud for wildcats was, on the average, $118,000 in 1958 with the astounding range of $10,000 for one well to $523,000 for another.

The advancement in mud compounds and the evolution of tools that can handle 18 lb per gal mud has much to do with controlling high pressures and high temperatures.

Operators

Most of the 92 operators in Table 7 handled drilling of at least one well that went below 15,000 ft. This means experience is spreading to greater numbers; improvement has more possibility.

Of the companies who drill a number of deep wells, Texaco continues to lead, but the number — 25 wells — were fewer than in 1957 when the com-

TABLE 7. DEEP WELL OPERATORS

Operator	Wells drilled 1958	Drilled before 1958	Total
Abercrombie, J. S.	0	1	1
Alcoa	0	2	2
American Petrofina	0	1	1
Anderson-Prichard	1	0	1
Atlantic Refining	1	0	1
Austral Oil Exploration	1	3	4
Belle Isle Corp	0	1	1
Block 27 Associated Ltd..	1	0	1
Brazos Oil & Gas Co.	0	2	2
British American	8	8	16
Brown, J. W.	0	1	1
Buffalo Oil	0	1	1
Burton, Wm. T., Ind.	2	1	3
California Co.	5	3	8
Callery, Inc., F. A.	0	1	1
CATC	0	1	1
Chacahoula O & G	0	1	1
Cities Service Producing	0	5	5
Cockrell, E. C.	1	0	1
Cole, H. S., Jr.	1	0	1
Columbian Carbon	0	2	2
Continental Oil Co.	6	13	19
Delhi-Taylor-Conoco	1	0	1
Denver Products & Ref.	0	1	1
Dillard & Waltermire	0	1	1
Drilling & Exploration	0	2	2
El Paso Natural Gas	0	1	1
Flaitz, J. M.	0	1	1
Frankfort Oil Co.	0	2	2
General Petroleum	0	2	2
Ginther, Warren & Co	1	1	2
Gulf Oil Corp.	8	28	36
Hawkins, H. L.	0	1	1
Houston Oil	0	1	1
Howell & Howell	2	3	5
Humble Oil & Refining	10	40	50
Hunt Group	6	9	15
Husky Oil	0	1	1
Kerr-McGee & Midwest	1	0	1
LaGloria Corp.	0	1	1
Lamson, Bennett & Cole	0	1	1
Little Nick Oil Co.	0	1	1
Lloyd Corp.	0	5	5
Lone Star Producing	2	0	2
McDermott, J. Ray	0	2	2
Magnolia Pet. Co.	2	31	33
Mayfield, M. L.	0	1	1
Mecom, John W.[2]	4	25	29
Mississippi River Fuel	2	1	3
Monsanto (Lion)	0	2	2
Monterey Oil Co.	0	3	3
Mountain Fuel Supply	0	1	1
Ohio Oil Co.	0	1	1
Olin Gas Transmission[1]	0	3	3
Owen, J. P.	1	1	2
Pacific Western	0	1	1
Pan American (Stanolind)..	12	35	47
Pano Tech Exploration	1	0	1
Pasotex Petroleum	0	1	1
Phillips	4	31	35
Placid Oil Co.	7	12	19
Pray, Max	1	2	3
Pure Oil Co.	1	6	7
Quintana	0	1	1
Republic Natural Gas	0	1	1
Richardson, Sid, Carbon[3].	4	26	30
Richfield Oil	0	2	2
Rutter & Wilbanks Bros..	0	1	1
Shell Oil Co	14	50	64
Shoreline Drilling	1	0	1
Sinclair	5	1	6
Skelly & Kin-Ark	1	0	1
Standard of California	1	17	18
Standard of Texas	0	1	1
Sun Oil Co.	8	12	20
Sunray Mid-Continent	1	6	7
Superior Oil Co.	8	29	37
Tennessee Gas Trans.	1	0	1
Texas Co.	25	103	128
Texas Eastern Trans.	1	0	1
Texas Gas & Gasoline	1	0	1
Texas Gulf	2	1	3
Texas Pacific C & O	0	1	1
Tidewater Oil	8	12	20
Trunkline Gas—Cyprus Oil.	1	0	1
Union of California	8	9	17
Union Oil & Gas of La.	4	9	13
Union Producing Co.	1	5	6
Vasen, George	0	1	1
Warren Petroleum	0	4	4
Western Natural Gas	0	2	2
Zapata Petroleum	0	1	1
TOTALS	192[4]	603	795

[1]One of Hunt Group
[2]Includes Mecom & Freeport wells.
[3]Includes Richardson & Bass
[4]Total includes some OWWO.

pany drilled 36 wells. This makes a total of 128 wells below 15,000 ft for Texaco, leading deep well operator.

Shell Oil Company drilled 14 deep wells, two more than in 1957. This totals 64 deep wells operated by Shell, second in number.

The interesting part of this deep well operators list is that 44 — almost half of the total of 92 — drilled only one well as deep as 15,000 ft. Add to this the hundred or more companies who contribute financially to deep operations and you have an indication of the wide sharing of risk in pushing down the seeking drill.

Big Rig Contractors

There are a greater number of contractors who have drilled to 15,000 ft than operators. Table 8 includes 102 contracting companies that in the last five years have drilled at least one super-deep well.

In early years the work was generally done by company rigs. Now contractors are responsible for the majority of deep wells.

Big drilling barges— like the "Mr. Louie" recently completed by Universal Drilling Company, New Orleans — expedite deep overwater drilling.

State Records

Louisiana has almost three-fourths of all deep wells — 577 out of 795 total for the nation. When you consider 27 of the 35 fields that produce below 15,000 ft are in Louisiana it isn't hard to see why that is where deep well operators go. Much offshore drilling is on the deep side, which adds to Louisiana operations.

Mississippi had a greater percentage increase in deep drilling than any state. Six were added last year to the eight drilled in previous years.

Deep Drilling Future

There is no reason at this point why drilling can't go on to new depths.

Equipment and service people believe they have materials available that will go 50,000 ft or close to it.[1]

Operators have taken a sensible, gradual course and economics favors this because production depths so far follow drilling records persistently. In the January, 1945, issue of The Petroleum Engineer (Page 214) we published a graph on production and drilling records from 1859. It showed close relation between the two curves, and the records since have gone deeper in about the same ratio.

Each new record well has been costly out of proportion to the average well that goes below three miles. Deep development well costs, however, have leveled off and given operators a chance for profits.

Weeks Island in Louisiana is still the prize deep reservoir (See Table 2) with 30 wells producing below 15,000 ft. A more recent deep field is Carter-Knox in Oklahoma, which already has 10 condensate-gas wells below 15,000 ft. Lake Barre field in Louisiana is a close third with nine deep producers.

Slim-hole deep drilling in Webb County, Texas, by Ginther, Warren and Company opens a new approach that could prove to be more efficient and less expensive. (See Page B-30.)

The amazing part of the whole deep drilling activity is that it is not halted by poor markets in a recession, by the oversupply aggravated by imports, by high costs when capital funds are low.

This year will see another record. Indications are that offshore drilling will add more than it has before to exploration of the depths. We expect approximately 230 wells to be drilled, 15,000 feet and below, in 1959. ★ ★

[1]"Could We Drill a 50,000-ft Hole?" *The Petroleum Engineer*, March, 1958.

THANKS TO

DEEP WELL OPERATORS

this survey is possible. We have had virtually total cooperation in gathering the information collected here. Our sincere appreciation goes to these oil companies that provide essential data, particularly cost figures.

TABLE 8. DEEP WELL DRILLING CONTRACTORS.

Aldridge & Stroud
Shreveport, La.

American Tidelands
New Orleans, La.

Arrow Drlg. Co.
Calgary, Canada

Atlas Drlg.
Opelousas, La.

Ballew
Fort Worth, Tex.

Bankhead Drlg. Co.
Baton Rouge, La.

Bay Drlg. Co.
Thibodaux, La.

Bell & Burden, Inc.
Los Angeles, Calif.

Big Chief Drlg. Co.
Okla. City, Okla.

Blackie Drlg. Co.
Franklin, La.

Booker Drlg. Co.
New Orleans, La.

Brewster-Bartle
Houston, Tex.

Brinkerhoff Drlg. Co.
Denver, Colo.

Zach Brooks Drlg. Co.
El Dorado, Ark.

Bullard Drlg. Co.
Houston, Tex.

Lyle Cashion, Inc.
Jackson, Miss.

Chance Drlg. Co.
Houston, Tex.

Circle Drlg. Co.
Lake Charles, La.

Clegg & Hunt
Houston, Tex.

Coastal Drlg. Co.
Bakersfield, Calif.

Coastal Marine Drlg. & Const.
Houston, Tex.

Continental Marine Expl. Co.
Houston, Tex.

Continental Shelf Drlg. Corp.
New Orleans, La.

Corbett Drlg. Co.
Odessa, Tex.

Crescent Drlg. Co.
Monroe, La.

Cren & Gracey Corp.
Houston, Tex.

Crown Drlg.
Houston, Tex.

Crown Rigs, Inc.
Houston, Tex.

Deep Water Expl.
Houston, Tex.

Delta Drlg. Co.
Tyler, Tex.

Delta Gulf Drlg. Co.
Tyler, Tex.

Dillard-Waltermire
Wichita Falls, Tex.

Dixie Drlg. Co.
Dallas, Tex.

Dixilyn Drlg. Co.
Odessa, Tex.

Doc Drlg. Co.
Golden Meadow, La.

Drilling & Expl., Inc.
Los Angeles, Calif.

Dyer Drlg. Co.
Lafayette, La.

Harry L. Edwards Drlg. Co.
Houston, Tex.

Falcon-Seaboard
Tulsa, Okla.

G. J. Foster Drlg. Co.
Richmond, Tex.

Gardner Bros. Drlg.
Dallas, Texas

Gilger Drlg. Co., Ltd.
Houston, Tex.

C. G. Glasscock Drlg. Co.
Corpus Christi, Tex.

Gordon Drlg. Co.
Lake Charles, La.

Gracey-Hollums
Houston, Tex.

Grey Wolf Drlg. Co.
Houston, Tex.

Gulf Coast Drlg. & Expl. Co.
New Orleans, La.

H. E. T. Drlg. Co.
Houston, Tex.

Hawkins-Wilkins
Houston, Tex.

Helmerich & Payne
Tulsa, Okla.

Hewgley Drlg. Co.
Midland, Tex.

Holmes Drlg. Co.
Houston, Tex.

Howell & Howell
Dallas, Tex.

Jett Drlg. Co.
Shreveport, La.

Kerr-McGee
Okla. City, Okla.

K. L. Kellogg Drlg.
Compton, Calif.

Carl B. King Drlg. Co.
Midland, Tex.

Larco Drlg. Co.
Jackson, Miss.

Loffland Bros. Co.
Tulsa, Okla.

Lowe Drlg. Co.
Midland, Tex.

Lu-Tex Drlg. Co.
San Antonio, Tex.

Mac Drlg. Co.
Houston, Tex.

Meadows & Walker Drlg. Co.
Houston, Tex.

John W. Mecom
Houston, Tex.

Mountain States Drlg.
Denver, Colo.

Nicklos Drlg. Co.
Houston, Tex.

Noble Drlg. Co.
Tulsa, Okla.

Noble Drlg. Co.
New Orleans, La.

Norton Drlg. Co.
New Orleans, La.

Offshore Drlg. Co.
Baton, Rouge, La.

J. P. Owen
Lafayette, La.

Owen Drlg. Co.
Overton, Tex.

Parker Drlg. Co.
Tulsa, Okla.

Penrod Drlg. Co.
Dallas, Tex.

Prince Drlg. Co., Inc.
Houston, Tex.

Producers Drlg. Co.
New Orleans, La.

Production Maint.
Houston, Tex.

Reading & Bates Drlg. Co.
Tulsa, Okla.

Richardson & Bass
Fort Worth, Tex.

Rocky Mtn. Drlg.
Los Angeles, Calif.

Grady Roper
Lake Charles, La.

Rowan Drlg. Co., Inc.
Fort Worth, Tex.

J. R. Sharp
Midland, Tex.

Shoreline Drlg. Co.
New Orleans, La.

Signal Drlg. Co.
Casper, Wyo.

Southeastern Drlg.
Dallas, Tex.

Steen Drlg. Co.
Houston, Tex.

Stewart & Douger
San Antonio, Tex.

Sun Drlg. Co.
Los Angeles, Calif.

Trans-Texas Drlg.
Longview, Tex.

Trinity Drlg. Co.
Dallas, Tex.

Tri-States Drlg. Co.
Laurel, Miss.

Viersen & Cochran
Okmulgee, Okla.

C. B. Webster Drlg.
Houston, Tex.

Dick Wegener
Okla. City, Okla.

Well Drillers, Inc.
Houston, Tex.

Western Service Drlg. Co.
Longview, Tex.

Wheless Drlg. Co.
Shreveport, La.

Marshall R. Young
Fort Worth, Tex.

Wesley C. Young
Sonora, Tex.

Zephyr Drlg. Corp.
Tulsa, Okla.

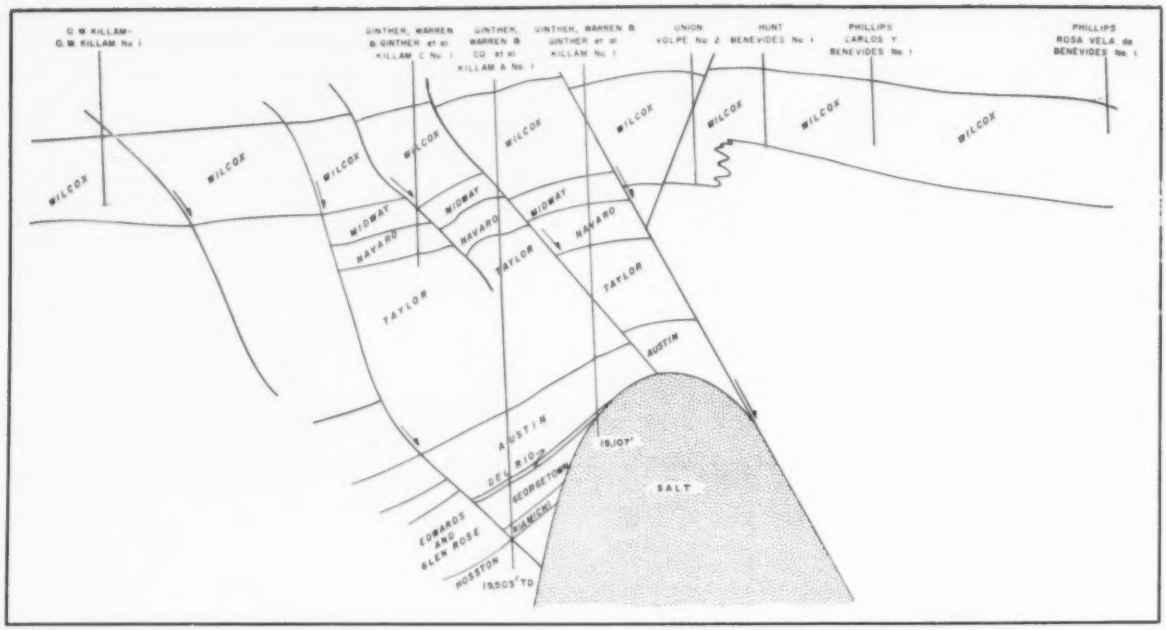


FIG. 1. **One interpretation** of the Pescadito structure using available data.

Ginther, Warren and Company et al successfully drill the . . .

WORLD'S SLIM DEEPEST HOLE

R. E. (Bob) Keen, *Ginther, Warren and Company, Houston, Texas*

OIL MEN EVERYWHERE are becoming more interested in the possibilities offered by the proper application of slim-hole drilling. In drilling the Ginther, Warren & Co. et al—O. W. Killam "A" No. 1, it has been conclusively proved that slim-hole techniques can be successfully employed in ultra-deep 20,000 ft drilling. And in this case, we are talking about true slim hole . . . a 4 9/16-in. hole was drilled from 16,536 to 19,503 ft.

This well was drilled under some of the most severe hole conditions to be found in any well . . . big hole, or, slim hole. For example, mud weights over 19.0 lb per gal were used, not just to slug the hole to control a potential blowout, but to drill a total of 2537 ft of hole to a depth of 16,537 ft.

The normal temperature gradient in Webb County down to a depth of about 7500 ft is 7.0 deg per 1000 ft. Projecting this gradient to reach a temperature of 420 deg F would require a depth of some 44,000 ft. However, at about 7500 ft the temperature gradient changes to 22 deg per 1000 ft. In the Ginther-Killam "A" No. 1, at 420 deg F temperature was recorded at 19,503 ft to make it the second hottest well ever drilled.

An open offset well, the Ginther, Warren & Ginther et al - O. W. Killam No. 1 (located 1¾ miles southeast of the Killam "A" No. 1 well) set a record as the hottest well ever drilled. In this well a temperature of 460 deg F was recorded at a depth of 15,107 ft. A comprehensive report on this well may be found in the October 1957 issue of *The Petroleum Engineer*.

The Pescadito Dome

The development history of the Pescadito Dome has been reported in considerable detail in the above-mentioned article. However, by way of review, this structure was mapped in the early 1930's by Dr. E. H. Sellards of The University of Texas. Since that date the structure has been seismographed many times and the Ginther-Killam No. 1 well made it the deepest known salt dome in Texas when it drilled into salt near the top of the dome at 14,394 ft.

The Pescadito structure has a closure of some 6000 ft, an aerial extent of about 50 square miles and a shape some 13 miles long and 7 miles wide, trending northeast-southwest. Fig. 1 shows an idealized cross-section of the salt dome. Fig. 2 is a map of the dome based on seismograph information on the Lower Cretaceous formation.

Wilcox Found Productive

A considerable number of wells have explored the Pescadito dome over the years but the first commercial production was not found until April 26, 1958 when Ginther, Warren et al O. W. Killam "B" No. 1 was completed in the Lower Wilcox for a gas-condensate producer. A second well has also found Lower Wilcox production one mile south of the discovery well.

Edwards Lime Production Sought

Three deep tests have been drilled on the west side of the Pescadito structure. The Sunray-Brewster-Bartle-Killam No. 1 was drilled in 1950 to a depth of 13,704 ft where high temperatures stopped further drilling. The two

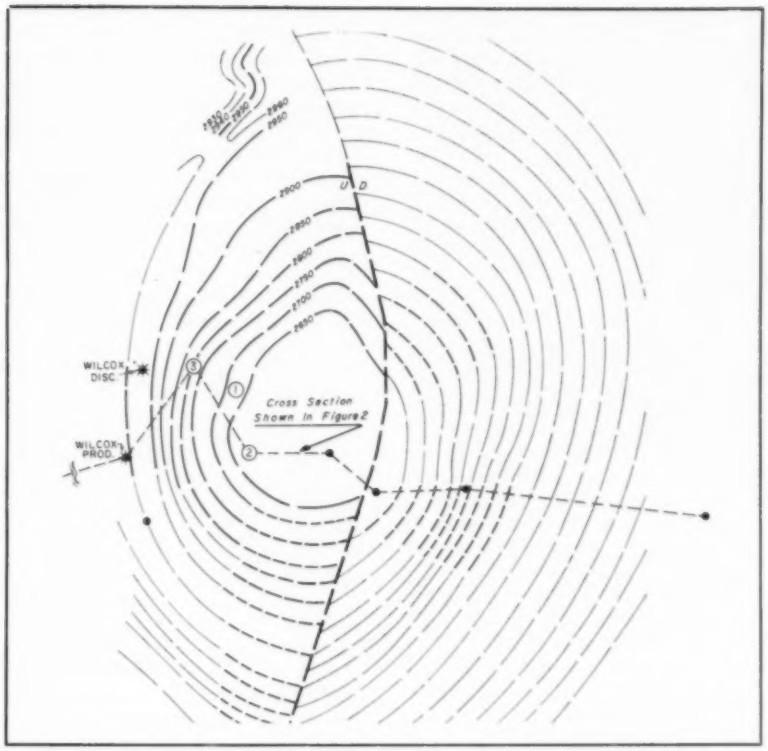


FIG. 2. **Contour map of the Pescadito Dome** based largely on seismograph data. The cross-section in Fig. 1 is shown and the location of the most important wells. Number 1 is the Sunray-Brewster-Bartle well. Number 2 is the Ginther-Killam No. 1 and Number 3 is the Ginther-Killam "A" No. 1.

others are the Ginther-Killam No. 1 drilled to 15,107 ft and into the salt dome; and the Ginther-Killam "A" No. 1 drilled to 19,503 ft — the subject of this article. Production in the Edwards would extend present production limits for this formation some 50 miles southeast and make it the deepest Edwards production.

Because the Ginther-Killam No. 1 penetrated the salt dome before reaching the Edward's Lime its primary objective was not accomplished. Therefore, it was necessary to drill the Ginther-Killam "A" No. 1 and a location was selected 1¾ miles northwest of Ginther-Killam No. 1, in the G. C. & S. F. R. R. Survey No. 1807 in Webb County, Texas, about 14 miles northeast of Laredo, Texas. This location was chosen to miss the salt dome but still be in a good location to find flank production in the Edwards. The first goal was achieved as salt was not encountered down to its total depth of 19,503 ft. However, at appears that the primary objective of reaching a good section of Edwards was not achieved.

Well records have been studied by expert personnel of four major oil companies and opinions are divided on just exactly what formations were penetrated at depths below 14,000 ft. One opinion is that the well bottomed in Hosston (basal Cretaceous) formation which would be below the Edwards. However, it could not be determined if any Edwards had been cut above the Hosston. Another opinion says the well did not reach the Edwards. The opinion of the operators is that the well did penetrate formations older than Edwards but failed to cut any Edwards because major faulting, or, truncation removed the Edwards from the area penetrated.

The effect of these opinions means that another well will be necessary to find and test a section of the Edwards that might be capable of producing gas or oil.

Drilling Operations

The Houston drilling firm of Dillard and Waltermire were chosen to drill the Ginther, Warren & Company et al Killam "A" No. 1. This firm successfully drilled the Ginther-Killam No. 1 and it used the same large rig for this well. The rig was equipped for ultra-deep drilling throughout and used three 625-hp diesel-fueled engines for a total of 1875 hp. The engines powered the drawworks and two of the largest and most advanced mud pumps through a compound. The two 8×18-in. mud pumps were equipped with 5½ and 6-in. liners and were capable of continuous pressures up to 3500 psi, using these liners.

The Edwards Lime was originally expected at about 16,500 ft but the casing program and other plans were made to go deeper if necessary. Fig 3 shows the tapered drill string used to drill this well.

Interval 0 to 7031 ft

The Ginther-Killam "A" No. 1 spudded December 14, 1957, and 307 ft of 16-in. conductor casing was set shortly thereafter. A 15-in. hole was drilled to 4550 ft and a 9⅞-in. hole to 7031 ft. After logging and taking side wall cores the 9⅞-in. hole was reamed to 15-in. and 10¾-in. casing set at 7015 ft.

Interval 7031 to 14,004 ft

A 9⅝-in. hole was drilled from 7015 to 14,004 ft and during this interval, mud weight was increased from 11.6 lb per gal to 17.8 lb per gal. This was necessary to prevent high-pressure gas from gas-cutting the mud and to keep sloughing shales from bridging and filling the hole during trips.

On March 26, 1958, a high-pressure

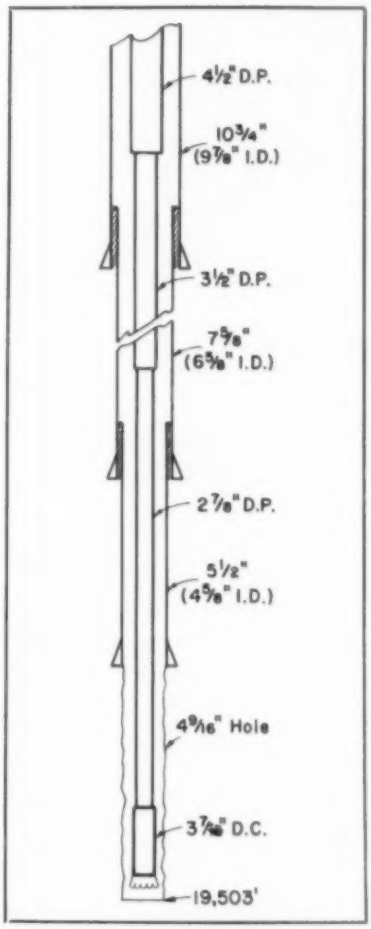


FIG. 3. **Tapered drill string** used to drill the Ginther-Killam "A" No. 1 as it neared total depth.

gas zone at 14,004 ft caused a blowout. There was no warning of the blowout on the mud logger or continuous weight recorder. The hydrostatic head at the blowout zone was computed to be 12,900 psi and the formation pressure was estimated at 13,500 psi. The hydraulic blowout preventer failed to close and it took about 30 min to partially close the mechanical blowout preventer. By this time most of the mud was blown from the hole through the casing annulus and two choke lines running to the reserve pits.

Immediately after the first heavy gas kick, mud was pumped from the reserve pit to the working pit, weighted to 18.5 lb per gal and pumped into the hole, but this failed to kill the well. About 45 minutes after the first gas kick, the gas flowing through the choke line caught fire. By this time the hydraulic preventer had been repaired and put back into operation. However, only one choke line could be closed and the pressure in the 10¾-in. casing annulus was 3700 psi. A favorable wind kept flames away from the rig and in another 40 minutes the hole bridged, shutting off the gas flow and permitting the remaining choke line to be closed.

About 600 bbl of mud was pumped from the reserve pit and conditioned to 18.5 lb per gal. This mud was pumped into the hole and circulation restored with a loss of about 150 bbl in volume and some loss in weight. The well would still kick so 19.0 lb per gal mud was circulated but the results were the same. A third try was made with mud weighing 19.5 lb per gal and containing 8 lb per gal of lost-circulation material. This batch successfully killed the well.

After the well had been killed it was found that the pipe could not be rotated or otherwise moved and pipe stretch indicated it was stuck at about 11,000 ft. To make fishing operations safe, the high-pressure gas zone at 14,004 ft was cemented. It was necessary to run a complete string of 2⅜-in. tubing (with special high-strength joints) inside the drill pipe to the bottom of the hole. The tubing string was used as a macaroni string to circulate the 19.4 lb per gal mud out of the drill pipe so the perforating gun could be pumped to bottom. However, when the drill pipe was perforated at 13,865 ft, just above the drill collars, the well kicked with 19.0 lb per gal mud in the hole. A second cement job using the special tubing string, effectively shut off this high-pressure gas zone.

The drill pipe was backed off at 7500 ft and washover and back-off operations were successful to 11,499 ft. A cement plug was spotted from 11,299 to 11,499 ft and dressed down to 11,399 ft preparatory to sidetracking. It required 28 days to complete these operations but the mud remained stable and required very little conditioning time.

On April 23, 1958, a whipstock was set at 11,390 ft and a 9⅝-in. sidetracked hole drilled to 13,202 ft. At this depth a 7⅝-in. liner was run and cemented from 6829 to 13,192 ft without any trouble. Fig. 4 charts drilling time in days and a brief record of the important formation tops at right.

Interval 13,192 to 16,537 ft

Drilling continued below the 7⅝-in. liner hung at 12,992 ft, with a 6⅝-in. bit. Mud weight was gradually increased to 19.3 lb per gal as the high-pressure gas zone was approached. At 14,069 ft gas cut the mud to 18.4 lb per gal but drilling continued and the mud returned to 19.3 lb per gal.

The drill pipe began to torque up, drag and hang up and at 14,500 ft became a serious problem. However, drilling continued to a depth of 16,537 ft by altering the drilling practice to include short trips off bottom every 24 to 36 hours, reaming the hole and circulating long periods off bottom before making a trip. The properties of the mud were changed and graphite was added but none of these techniques helped. There are several conditions which might be the reason for this trouble but the primary cause was never determined.

The possibility of a crooked hole causing the difficulty could not be confirmed because at this depth the bottom-hole temperature burned up the film used to record the deviation angle.

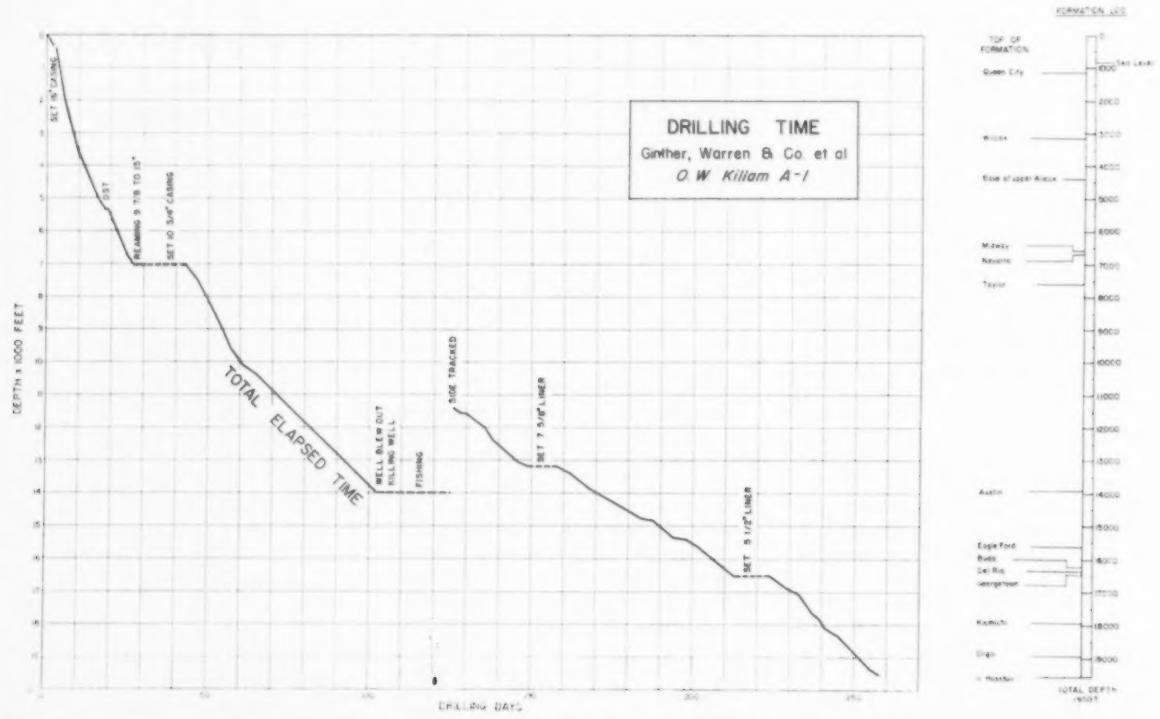


FIG. 4. **Drilling time chart** for the Ginther-Killam "A" No. 1 well with a stratigraphic log of the well at right.

Large pieces of hard, dense (SP 2.55) and brittle shale were frequently pumped out of the hole. The pieces were easily noticed because they tended to float in the heavy 19.0 - 19.5 lb per gal mud (SP 2.33). The larger pieces had a concave shape and were marked as if they had been in contact with the rotating drill pipe. One theory reasons these large pieces would accumulate in cavities and fall in around the drill pipe in a large mass from time to time. No attempts were made to locate or clean out any possible cavities.

There was never any indication of poor mud properties at the bottom of the hole in spite of high mud weights and hole temperatures. Circulation was obtained with even abnormally low pump pressure and mud off bottom following trips was usually in good condition; often in better condition than mud anywhere else in the system.

It was decided to attempt running an electric log at this depth, 16,537 ft, and to set a 5½-in. liner to eliminate further risk of sticking the drill pipe. In preparation for logging, the hole was reamed from 14,400 to 14,600; 15,100 to 15,700 ft; and 15,900 to 16,537 ft which took 6 days. Logging was accomplished without any difficulty and a bottom-hole temperature of 350 deg F was recorded.

The men responsible for the development of the gigantic Pescadito Dome faced many tough decisions requiring a great faith in its production possibilities. The operators chosen for this job are pictured above. From the left: Howard C. Warren, Wilbur L. Ginther, George C. Clement, and R. E. Keen (author), all of the firm Ginther, Warren and Company. Other men and firms participating were: S. G. Sanderson, H. G. Beardmore, T. R. Deen and L. H. Moore, all of Gulf Oil Corporation. Also, Michael T. Halbouty, Houston independent, and O. W. Killam, lessor and independent operator.

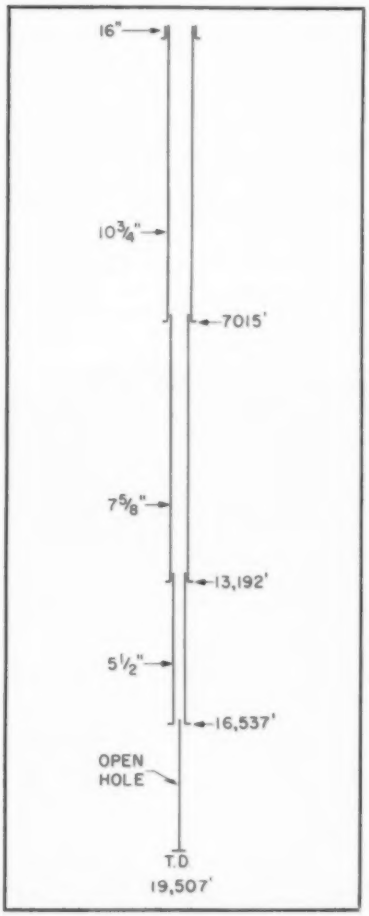


FIG. 5. **Casing program** for the Ginther-Killam "A" No. 1.

Interval 16,537 to 19,503 ft

A 4½-in. rock bit was used to drill out of the 5½-in. liner shoe, but the remainder of the hole was drilled with 4 9/16-in. diamond bits.

While drilling at 18,250 ft a tool joint washed out and parted the 2⅞-in. drill pipe at 13,780 ft. The mud in the hole remained undisturbed for 10 hours before a new pin was screwed into the fish. Circulation was easily established and the fish was completely free. After a round trip to inspect the bit, drilling was resumed.

After the total depth of 19,503 ft was reached August 30, 1958, the hole was logged and while reaming at 19,502 ft preparatory to testing, the 2⅞-in. drill pipe twisted off at 13,280 ft. It was necessary to have a special overshot made and the fish remained on bottom for about 20 hours but was easily recovered.

After extensive formation testing a cement plug was spotted from 10,260 to 10,460 ft and the well abandoned on September 30, 1958. A total of 258 days elapsed from the time the well was spudded until the total depth was reached. Testing and plug and abandonment operations consumed another 30 days.

Casing Program

The casing program is shown in Fig. 5. Smaller diameter casing was used for the Ginther-Killam "A" No. 1, although it was known that it would be drilled deeper than either of the two previous deep tests. A 16-in. conductor was set at 307 ft in 22-in. hole and cemented with 420 sacks to the surface. A 10¾-in. protective string was set at 7015 ft in 15-in. hole. The bottom section was cemented with 1300 sacks and the top section with 765 sacks through a stage tool set at 1900 ft. This program saved about $48,000 compared with the casing program for the Ginther-Killam No. 1.

The serious blowout at 14,004 ft which made it necessary to sidetrack the hole beginning at about 11,400 ft, forced the operators to set a 7⅝-in. high-strength (P-110 grade) protective liner at 13,192 ft before re-entering the high-pressure blowout zone. The mud in the hole at this depth weighed about 18 lb per gal so it was necessary to add special weight material to the 1107 sacks of cement used, to increase its density to that of the mud. Mud returns were lost when the cement started around the bottom of the liner and never regained. A temperature survey, however, indicated top of the cement at 6800 ft. A large temperature anomalie at this depth indicated a lost-circulation zone and being some 200 ft above the top of the liner, it was considered to be satisfactorily cemented in place.

A high-strength (P-110 grade) 5½-in. liner was run from the upper 7⅝-in. liner to 16,537 ft and cemented with 186 sacks. A temperature survey could not be run because of high bottom-hole temperatures. There were no indications of any trouble during cementing

so a satisfactory cement job was assumed. This particular high-strength liner was chosen to permit passage of a 4 9/16-in. bit to drill the remainder of the hole.

No serious trouble was experienced with any of the casing in the hole during drilling and testing operations, and the cement jobs on the casing proved satisfactory.

Bit Record

A total of 92 bits were used ranging from 22-in. down to 4½-in.; 83 were rock bits and 9 were diamond bits.

Interval 0 to 7031 ft

Two 22-in. rock bits drilled from the surface to 330 ft to make hole for the 16-in. conductor string.

A 15-in. hole was cut from 330 to 4550 ft and a 9⅞-in. hole from 4550 to 7031 ft. This lower section was then reamed to 15-in. preparatory to running 10¾-in. casing. A total of 16 bits, 15-in. in diameter and nine, 9⅞-in. bits were used for all drilling and reaming in this interval.

Interval 7031 to 13,202 ft

A 9⅝-in. hole was drilled from 7031 to 14,004 ft where the well blew out. Thirty-two 9⅝-in. bits were used to drill this interval. The hole was then plugged back and sidetracked at 13,400 ft and drilled to a depth of 13,202 ft with nine 9⅝-in. bits, making a total of 41 bits of 9⅝-in. size used. A 7⅝-in. liner was then run from 6850 to 13,192 ft.

Interval 13,202 to 16,537 ft

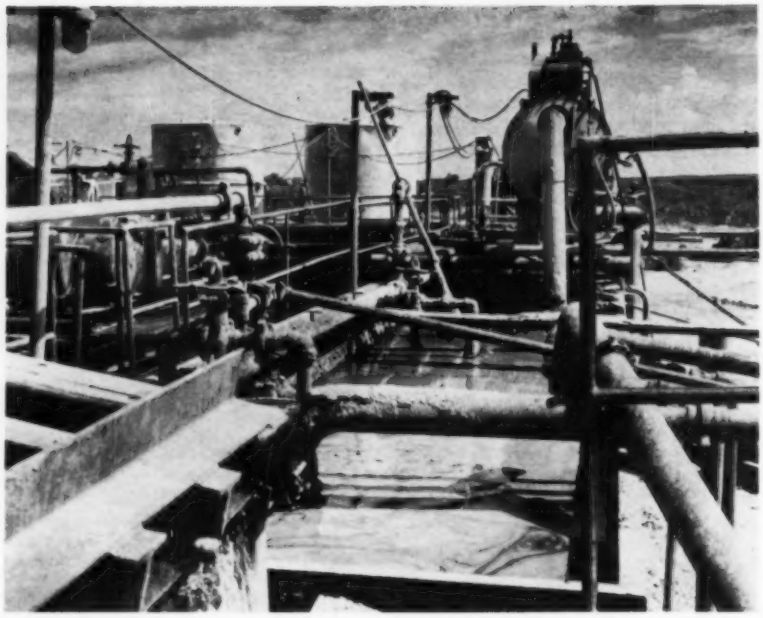
A 6⅝-in. hole was cut from top to bottom of this interval which required 13 rock bits and 3 diamond bits, 6 9/16-in. in diameter. The rock bits drilled 1144 ft of this 3335 ft interval, averaging 88 ft per bit. These bits run on bottom an average of 21½ hours and drilled at an average rate of 4.1 ft per hr.

The 3 diamond bits drilled 2191 ft and averaged 730 ft per bit. The 3 bits drilled a total of 514 hours and averaged 4.2 ft per hr.

Drilling rate of the two type bits were almost the same and the diamond bits cost an average of $2.89 per ft against $1.85 per ft for rock bits. However, the diamond bits effected an appreciable overall saving by requiring a trip only every 730 ft on the average compared to one every 88 ft on the average for rock bits. A 5½-in. liner was run from 13,192 to 16,537 ft.

Interval 16,537 to 19,503 ft — Total Depth

The 4½-in. rock bit used to drill out of the 5½-in. liner was apparently damaged by this operation as it made only 44 ft. The remainder of the hole was cut with 6 diamond bits, 4 9/16-in. diameter. The 6 diamond bits drilled a total of 2922 ft averaging 488 ft per bit. The average bit stayed on bottom 93 hours and drilled at an average rate of 5.2 ft per hr compared to 4.2 ft per hr for the 6 9/16-in. diamond bits. Bit costs averaged $3.12 per ft.



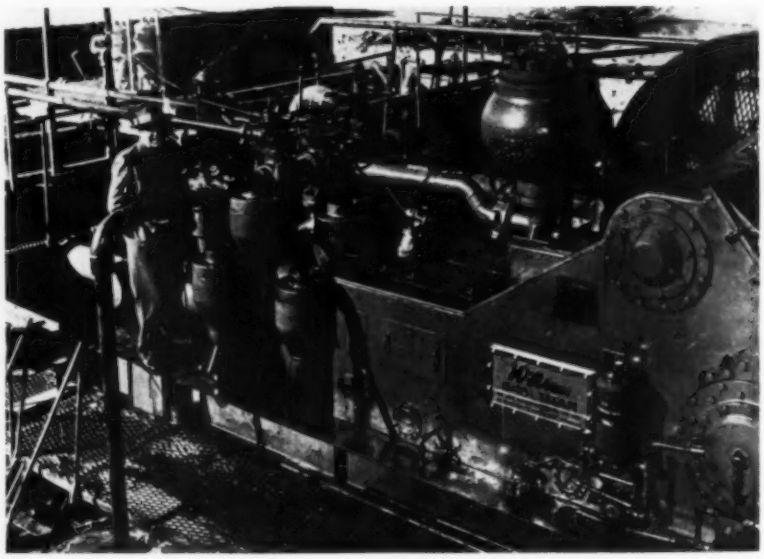
View of the mud system showing the big degasser used to keep the mud free of entrained gasses.

Mud Program

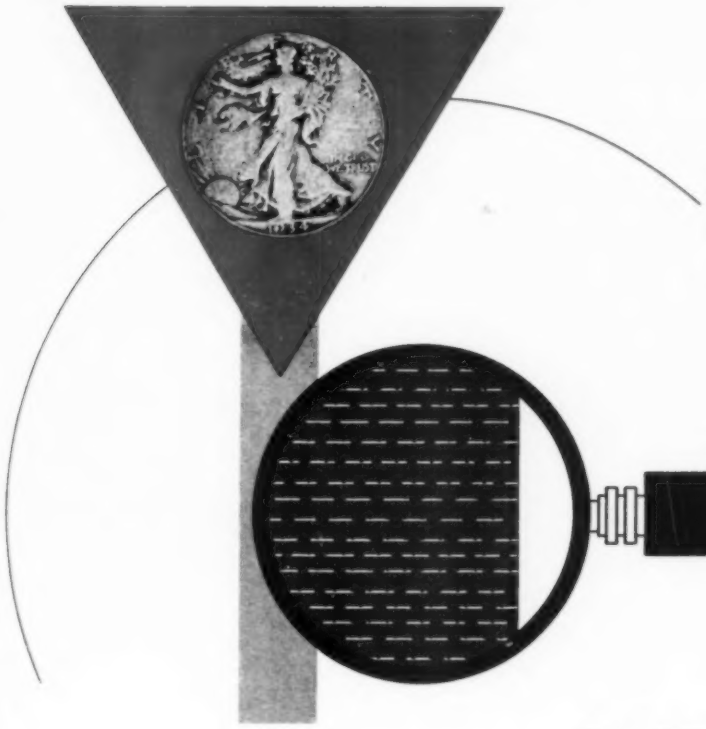
The special low sodium surfactant mud proved to be one of the most important tools used in the drilling of this deep, high temperature well. This same statement can be made for the Ginther-Killam No. 1 well which was reported in the October 1957 issue of *The Petroleum Engineer*. For additional details of this relatively new type mud, this article should be reviewed.

This type mud was selected because of its excellent stability at extremely high temperatures. It does an outstanding job of controlling the rheological (viscosity) properties of the mud at high temperatures, but probably its most important property is that of controlling water loss with a minimum use of water loss control agents.

In an extremely deep or hot well, one of the most serious problems in addition to that of gellation or cementation, is the filtration control problem.



View of one of the two huge 8 x 18 in. pumps used to drill this well. Fred Waltermire, vice president of Dillard-Waltermire, Inc., is shown standing near the pump.



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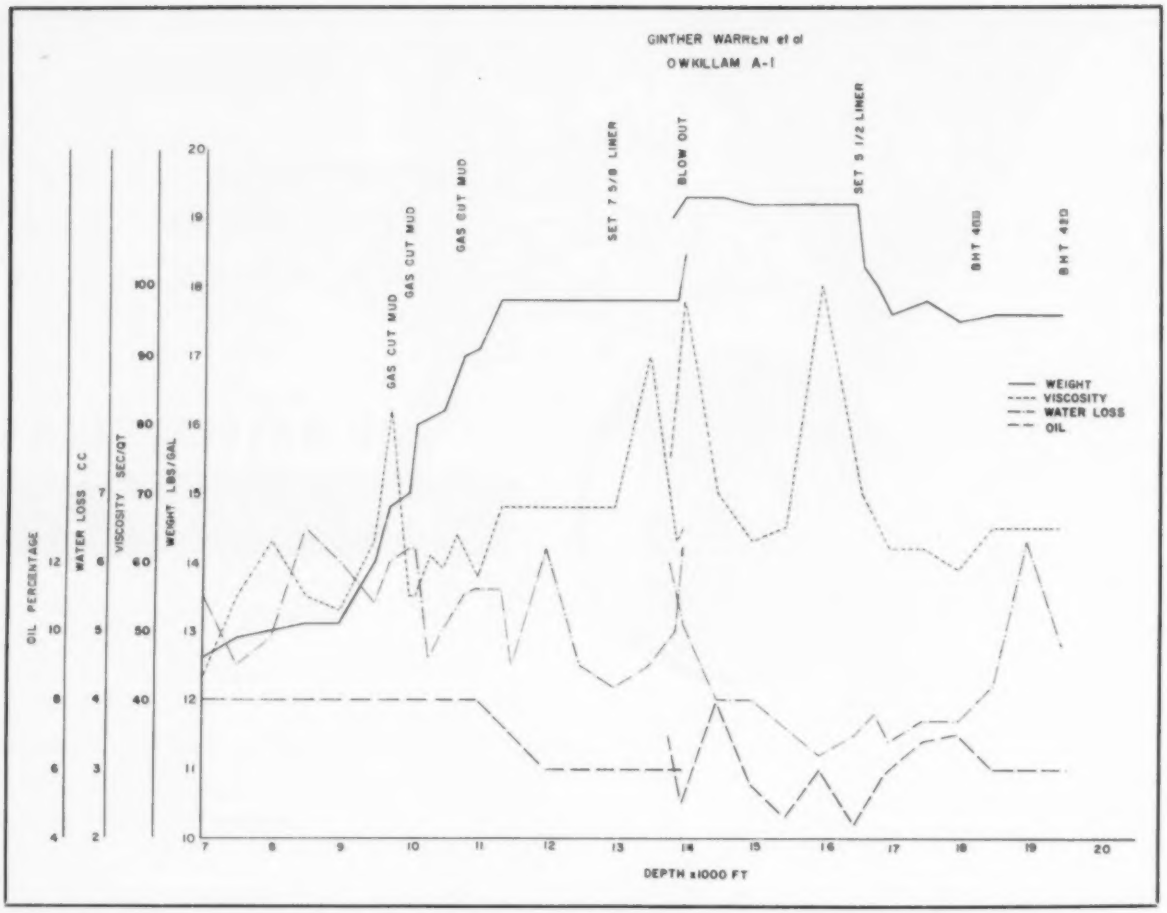

FIG. 6. **Mud properties** of the low-sodium surfactant mud used to drill the Ginther-Killam "A" No. 1 starting at a depth of 7000 ft.

Under these conditions filtration control was obtained through the use of a fluid loss control supplement, HS400 which is also a very efficient emulsifier. The primary surfactant material used in this case was DMS (Drilling Mud Surfactant) which was originally developed by Magnolia Petroleum Company.

The surfactant material increases the lubrication properties of the mud by its ability to plate out on metal surfaces, sides of the hole, or, any surface it may contact. This is one of the important characteristics which gives this mud an unusually low friction factor.

Interval 0 to 7031 ft

This section of hole was drilled with lightly treated native mud which had a relatively low pH, a viscosity of 85 to 95 seconds per qt and a density of 13.2 lb per gal at the 7000 ft depth.

Other than minor shale problems there was no difficulty with the mud or in drilling this interval which consisted mostly of soft gummy shales with sandstone stringers and hard, dense, brittle shale sections.

Interval 7031 to 14,004 ft

At this depth a mud degasser and other automatic mud control equipment were installed. The native base mud used in the earlier depth interval was converted to a low-sodium surfactant base mud with the following properties: Viscosity 42 seconds per qt, density 11.6 lb/gal, fluid loss 5 cc, pH 9.3, salt 12,375 ppm, oil 8 percent. The flowline temperature at the 7000 ft depth measured 142 deg F. Fig. 6 plots the most important properties of the surfactant mud starting at a depth of 7000 ft.

At 9464 ft a drilling break occurred and the 14 lb mud was gas cut to 11 lb. Mud weight was increased to 15 lb and at 10,163 ft it was necessary to again increase mud weight in excess of 16 lb per gal. Abnormal high-pressure gas zones made it necessary to continue the rapid increase of mud weight to control these zones.

At 11,563 ft, approximately 300 bbl of mud was lost. At this time the mud contained about 5 lb per bbl of fine granular material and 3 lb per bbl of fine flake material as a preventative measure. By waiting 3 hours while making a trip a seal was accomplished.

The well was logged at a depth of 13,944 ft and it was planned to set the 7⅝-in. liner at this point. However, the log did not afford a good stratagraphic correlation and because a show of porosity was indicated at the base of the log, plans were altered to drill ahead for one more bit.

While drilling a few feet deeper, at 14,004 ft, the well started kicking and the hydraulic blowout preventer failed to operate. The sequence of this blowout and its kill operation has been described earlier in the drilling operation section. After controlling the blowout, and cementing off the high-pressure gas zone, the well was plugged back and the hole sidetracked. The hole was redrilled in a sidetracked hole to a depth of 13,202 ft without any difficulty and the 7⅝-in. liner was run to a depth of 13,192 ft.

Interval 13,202 to 16,537 ft

As drilling progressed below the 7⅝-in. liner and approached the blowout zone at 14,000 ft, the mud was increased to 19.3 lb. And at 14,069 ft the mud was cut from 19.3 to 18.4 lb but was quickly increased to 19.3 lb which permitted drilling to continue without the mud being gas cut.

At this depth began an interval of some 2537 ft when the mud weight was never less than 19.2 and as high as 19.5 lb. During this interval the viscosity was maintained between 60 and 85, pH ranged from 8 to 9.3, and fluid loss ran 4 cc; salt content was 12,000 ppm and the flowline temperature was 177 deg F. Four important mud properties are plotted in Fig. 6 starting from a depth of 7000 ft.

Viscosity and fluid loss were the two most difficult properties to control during this interval of ultra-high mud density. This was because of the high percentage of solids in the mud necessary to achieve the high mud weight. In the 19.5 lb mud, the solids by volume were about 41-43 percent. This plus an oil content of 6 percent, meant that up to 49 percent of the mud was solids or non-aqueous material. As a result, even minor increases in solids from drilled formation or other sources would cause an increase in viscosity. The same effect would be caused by the additions of fluid loss control agents, oil or barite. Thus the treatments of the mud system were carried slowly and uniformly to avoid a sharp increase in viscosity.

During one period the fluid loss was lowered to 2.0 cc in an attempt to improve hole conditions. However, this did not help and the high concentration of conventional fluid loss control agents necessary to maintain the fluid loss at this low value made the viscosity of the mud system difficult to control.

In general, the fluid loss was controlled at 3-4 cc with the addition of a surfactant fluid loss control supplement HS400, and by maintaining the oil content at about 6 percent by volume. This made it much easier to control the other mud properties, as conventional fluid loss agents were not necessary.

At a depth of 16,537 ft, a 5½-in. liner was run to case-off this troublesome section of the hole.

Interval 16,537 to 19,503 ft

A 4 9/16-in. hole was drilled below the 5½-in. liner to a total depth of 19,503. After drilling a short period below the liner, the mud weight was reduced to 17.8 lb per gal where it was held for the remaining portion of the hole. This permitted maintaining all the desirable properties of the mud much easier and less expensively. It also permitted a faster drilling rate, and it was during this interval that the use of the centrifuge was of most value in recovering barite from the reserve pits.

This portion of the hole was drilled with very little difficulty and the gradual increase of bottom-hole temperature to a maximum of 420 deg F at the total depth of the hole did not adversely affect the mud properties. The following mud properties were measured while drilling near total depth: Weight — 17.6 lb per gal, viscosity — 79 seconds per qt, pH — 8.8, fluid loss — 4.2 cc, chloride content — 2300 ppm, calcium — 200 ppm, oil — 6 percent, gel strength 8 and 17, filter cake — 2/32 in. surfactant content — 2.3 lb per bbl, solids — 36 percent, by volume. Fig 7 plots the mud weights for the 3 deep tests. Fig. 8 shows the subsurface temperatures for these 3 wells.

There was considerable concern from the start as to just how deep

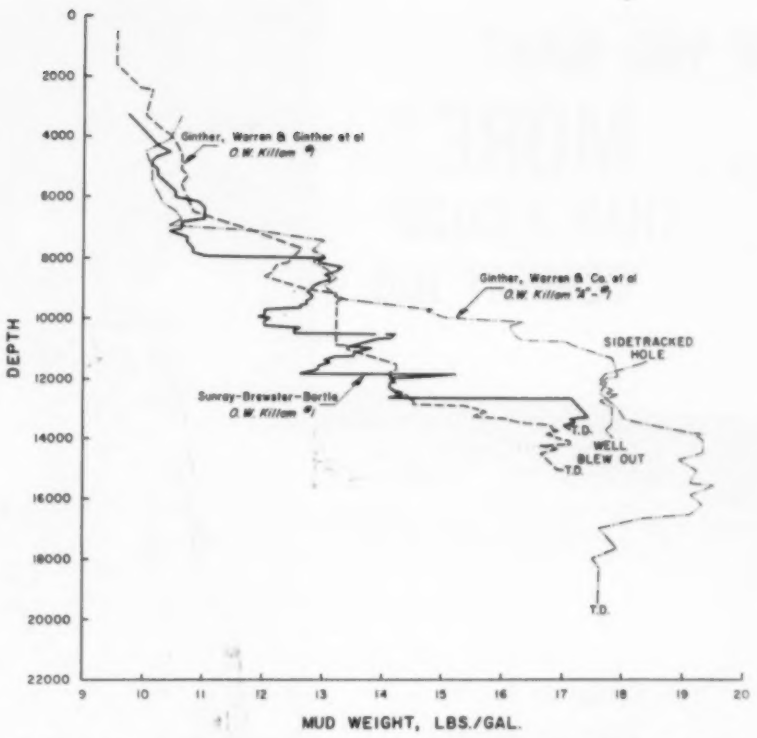

FIG. 7. **Mud weights are compared** for the three deep tests drilled on the Pescadito Dome.

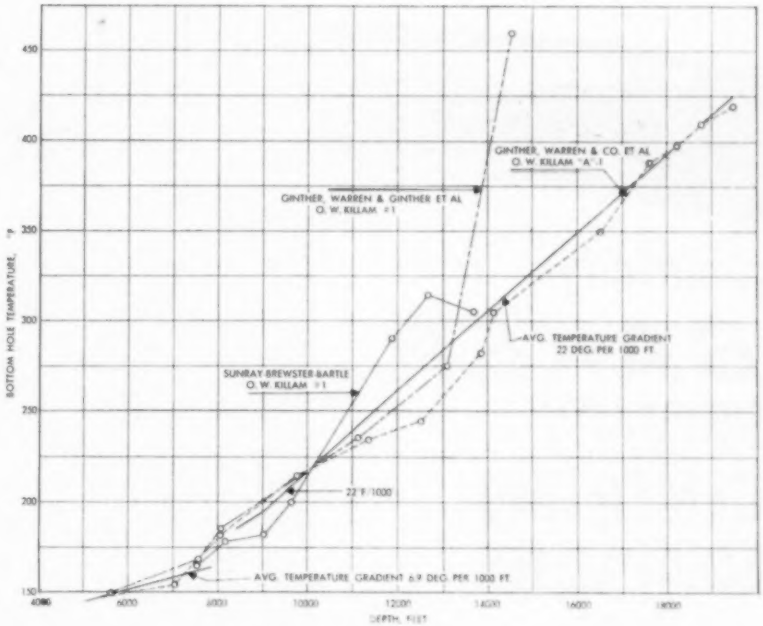
BOTTOM HOLE TEMPERATURE, °F
DEPTH, FEET
GINTHER, WARREN & CO. ET AL O. W. KILLAM "A" 1
GINTHER, WARREN & GINTHER ET AL O. W. KILLAM #1
AVG. TEMPERATURE GRADIENT 22 DEG. PER 1000 FT.
SUNRAY BREWSTER BARTLE O. W. KILLAM #1
22 °F/1000
AVG. TEMPERATURE GRADIENT 6.9 DEG. PER 1000 FT.

FIG. 8. **Temperature gradients** for all three deep tests and normal temperature gradients which change at about 7500 ft have been plotted for comparison.

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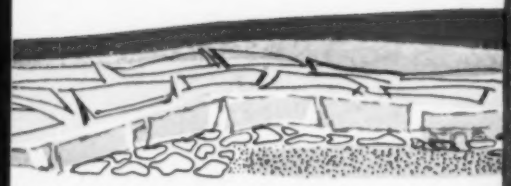

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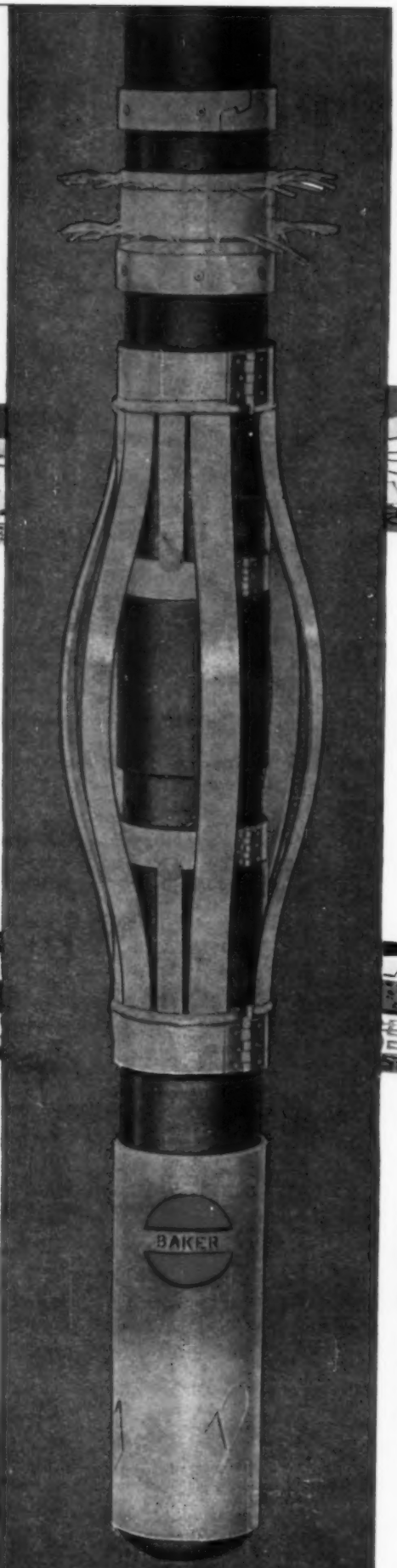

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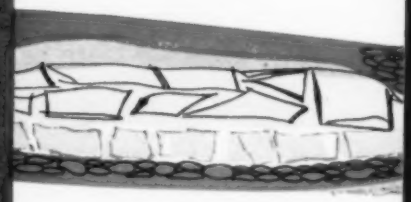

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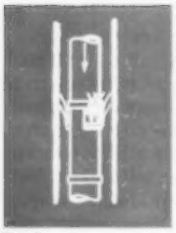

Fig. A

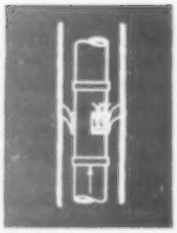

Fig. B

Fig. C

Fig. A Scratcher wires, retained by integral hinged mounting, swing freely upward and do not remove mud cake while running in.

Fig. B Even when casing is lifted out of the slips, the entire Scratcher remains stationary. Only when reciprocated, and

Fig. C ...only at the cementing area does the "scissors" action of the crossed wires remove mud cake.

Baker Scratchers remove mud cake only from the cementing area; this "controlled scratching" protects productivity.

While running in, the scratcher wires automatically swing upward along the casing, where they are safe from damage; permit free, unrestricted lowering of the casing; and do not disturb or remove mud cake. There is no danger of "balled-up" mud collecting on the scratcher wires to plug the annulus and contribute to pressure surges with possible "mudding-off" of the producing zone. Only when the cementing area is reached and the casing is reciprocated do the double rows of strong "crossed" spring wires automatically reach out, dig in, and remove the mud cake with efficient "scissors" action.

Fig. D

Fig. E

Fig. F

Fig. D "Extended" Range HINGE-LOK Baker H-25 Casing Centralizer Product No. 9113.

Fig. E "Normal" Range HINGE-LOK Baker H-20 Casing Centralizer Product No. 9112.

Fig. F "Slim Hole" SOLID-RING Baker G-15 Casing Centralizer Product No. 910-G.

Baker Centralizers assure cementing clearance. "No-scrape" design prevents "balling", plugged annulus and stuck casing.

The QUALITY of Baker Casing Centralizers starts with "sled-runner" springs made of high quality spring steel—tested and pre-set by flattening in hydraulic presses—then butt-welded to collars to form a unit of great strength. Pre-setting of the springs to the pre-calculated optimum bowed height enables each centralizer to pass tight spots or dog legs without damage to the assembly, and ensures GREATER CENTERING FORCE for maintaining annular clearance for cementing.

Baker Centralizers do not remove mud cake which could plug the annulus, contribute to pressure surges and restrict productivity.

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Fig. G

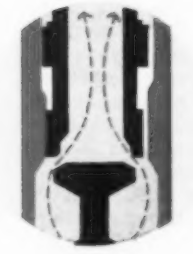

Fig. H

Fig. G Variable FILL-UP Valve as used in FLEXIFLOW Equipment.

Fig. H Variable FILL-UP Valve as used in DIFFERENTIAL Equipment.

Baker Fill-Up Equipment saves time in running casing, but does not create pressure surges that reduce productivity.

Destructive pressure surges—often created when casing equipped with conventional floating equipment is lowered into the well—can now be avoided. The Variable Valve in either Baker DIFFERENTIAL or Baker FLEXI-FLOW "Fill-up" Shoes and Collars, permits casing to fill from the bottom up; eliminates expensive, time-consuming surface filling; and automatically coordinates the *rate of fill* with the *rate of lowering* to AVOID high pressure surges. Baker FILL-UP Equipment permits the casing to be lowered at normal rates, saving rig time and reducing danger of sticking the pipe; chances for successful primary cementing are increased; formations are protected from high pressure surges which can impair their productivity.

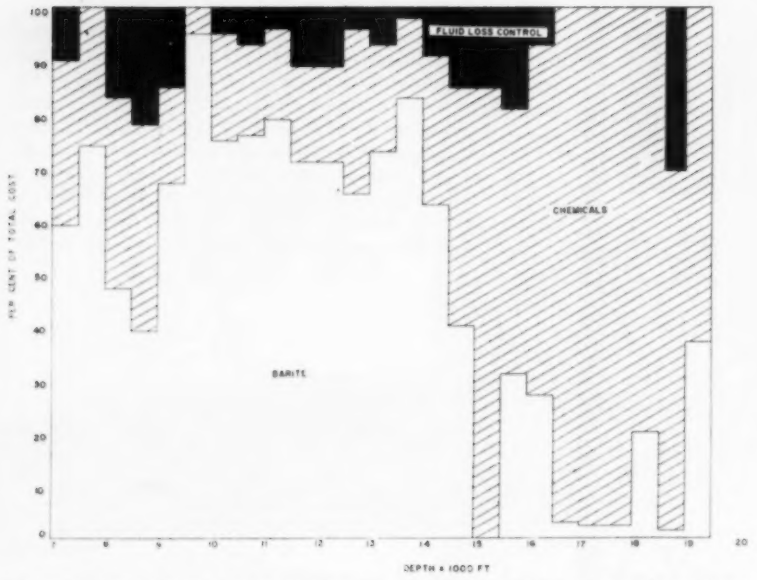

FIG. 9. **Drilling fluid costs** of the Ginther-Killam "A" No. 1 well in percent of the total costs for the various materials used.

this hole could be drilled with the limitations of this hydraulic set-up and the maximum pump pressure of approximately 3500 psi. Existing friction factors for all types of mud were closely examined but it was not possible to determine a friction factor for the surfactant mud being used with any degree of reliability. However, using a favorable friction factor for a low viscosity mud together with the other limiting factors of the hydraulic system, a computation to determine how deep the well could be drilled was made. From these data it was determined that circulation could not be established deeper than 17,200 ft. However, at the time this answer was obtained, the well was currently drilling at 18,200 ft and pump pressure was 3200 psi. Pump pressure reached a maximum of 3400 psi at a total depth of 19,503 ft.

While circulating at a total depth of 19,503 ft mud return volumes were measured and it was calculated that the annular velocity between the 2⅞-in. drill pipe and the 4 9/16-in. hole was 266 ft per min. In the intermediate section with the combination of 7⅝-in. casing and 3½-in. drill pipe, the velocity was 213 ft per min. And in the upper section with the combination of 10¾-in. casing and 4½-in. drill pipe, the mud velocity was 46 ft per min. Good returns were obtained at even the low 46 ft per min rate primarily because of the high mud density and the other good mud qualities which permitted the cuttings to be carried from the hole efficiently. The mud cost is broken down into three main categories of barite or weighting materials, cost of chemicals, and cost of fluid-loss control agents. Actually, mud costs for the slim-hole section below 16,503 ft were much lower than for any equivalent section of hole above this depth. Fig. 9 shows mud costs vs depth for this well.

Logging Program

Down to a depth of 11,000 ft or a bottom-hole temperature of about 250 deg F there was no difficulty with any of the logging equipment. However, at greater depths the ES log was the only one that could withstand the elevated temperatures, with the exception of the microlog and the sonic log which were run at 13,944 ft. The sonic log was particularly valuable in determining zones of porosity at this depth. This information was badly needed as it served as a source of detection of high-pressure gas zones.

The first log was run at 7030 ft, just prior to running the 10¾-in. string. At 11,306 ft, a second log run was made. At 16,537 ft, a temperature measurement was made which recorded a bottom-hole temperature of 350 deg F.

Temperature recordings were made with three mercural maximum thermometers; two were in upright position and one placed in reverse position. At 18,250 ft another temperature log was run which recorded a bottom-hole temperature of 400 deg F. At 18,800 ft, a bottom-hole temperature of 409 deg F was logged, and 19,503 ft, total depth of the hole, a maximum reading of 420 deg F was obtained. In this case the logging instrument went to the bottom without any trouble, in a little over 50 minutes.

It is interesting to note that down to a depth of about 7500 ft both the temperature gradient and pressure gradient followed a normal pattern. The temperature gradient down to this depth is about 7 deg per 1000 ft. An average of the 3 deep tests show that below this depth, the gradient averages about 22 deg per 1000 ft on to the total depth of Ginther-Killam "A" No. 1. An exception was the Ginther-Killam No. 1 which had a higher temperature gradient near the bottom of the hole due to the vicinity of the salt dome itself and by drilling into the salt. It had a temperature gradient from 13,000 ft on to its total depth of 15,107 of about 128 deg F per 1000 ft.

Testing Program

In the interval below the 5½-in. liner which was set at 16,537 ft, it was extremely difficult to know exactly which zones should be tested. The additional problems of extremely high temperatures and an uncased small diameter hole would have made it a very precarious and expensive operation to carry out any extensive testing program under these conditions. On this basis it was decided to set a packer at 16,500 ft in the 5½-in. liner and test the entire open-hole zone section at one time. Then if any favorable gas or oil shows developed, further testing would be considered. The arrangement of test tools for this testing operation is shown in Fig. 10.

The mud in the test string (drill pipe) was displaced with water requiring a pump pressure of 8000 lb. This pressure bled down in 20 minutes and the drilled pipe was swabbed to 10,120 ft without any results. The test string was then filled with water and the formation broke down at 9750 lb. 12½ bbl were pumped into the formation at a maximum pressure of 10,600 lb without any results. These tests were considered conclusive that no commercial gas or oil zones existed below 16,537 ft.

A bridge plug was then set at 11,410 ft in the 7⅝-in. liner and the next test was performed at a depth of 11,236 to 11,300 ft. The 7⅝-in. liner was perforated with 8 shots per ft over this interval. Gas had been encountered in originally drilling this section and was indicated on both the mud logger and the formation log. However, no cores were taken. It was necessary to squeeze both above and below the test interval before perforating for possible production.

After extensive testing, this zone was found non-productive although a small gas flow was recorded. Extensive squeezing was necessary to effectively plug off this zone.

The third and final zone was tested from 10,744 to 10,754 ft. This zone was also block squeezed before testing. The well tested dry, natural, and the formation was treated with 1000 gal of mud acid which was displaced at 5800 psi. On a ¼-in. choke, pressure bled down to 200 lb in 6 minutes and this zone also proved to be dry. A 50-sack cement plug was set from 10,460 ft to 10,240 ft and the hole abandoned.

Cost Summary

The total cost of this well was not out of line with other wells to this extreme depth. If the expense of the blowout could be deducted, the well could be said to have a lower than average cost. Good planning, equipment and qualified personnel in all phases of this operation were basically responsible for cost being held to a reasonable figure. However, it should be emphasized that the excellent performance of the surfactant mud was responsible for greater savings than any other one factor. This, of course, in addition to the fact that it would not have been possible to drill below about 14,000 ft without this mud. A minimum of time was required for conditioning and circulating after making a trip which permitted the majority of rig time to be spent making hole. Diamond bits were also helpful in reducing the number of trips and thus increasing appreciably the percentage of time which could be spent drilling.

Table 1 gives a breakdown on major cost items and the percent of the total which was spent for each of these items.

TABLE 1. Cost Summary.

Item	*Percent of Cost*
Total Contractor's Cost	41.56
Mud and Chemicals	25.46
Casing and Cementing	15.35
Equipment Rentals	5.85
Bits	3.71
Electrical Logs, Surveys	2.96
Water and Diesel Oil for Mud	2.44
Hauling	1.22
Geological and Engineering Supervision	0.98
Roads, Location, Pits	0.24
Miscellaneous Supplies and Services	0.23
	100.00

Conclusions

The outstanding achievements of this well may be listed as follows:

1. The drilling of 2966 ft of 4 9/16-in. hole below 16,537 ft with hole temperatures ranging from 350 to 420 deg F.
2. The drilling of 2537 ft of 6 9/16-in. hole below 14,000 ft with ultra-heavy mud weights of 19.2 to 19.5 lb per gal and hole temperatures ranging from 300 to 350 deg F.
3. This was the deepest well in East and South Texas.
4. It was the second hottest well ever drilled in the world.

There were many difficult hole conditions to complicate the drilling of this well.

For example, all of the achievements listed above were performed in a sidetracked hole. High temperatures affected nearly everything that went into the hole, such as drill pipe rubbers and packer rubbers. None of the hole below 11,000 ft could be throughly logged, and the remote location of the well made supplies difficult to obtain particularly on emergency basis.

This well also confirmed and broadened some of the findings learned in the drilling of the Ginther-Killam No. 1. It was known that this would withstand extremely high temperatures very well, but what about its pumpability at great depths and in slim hole? New and encouraging data have been determined proving low friction losses for this mud, not in the laboratory but under actual field conditions. This information should be valuable to those responsible for drilling to depths of 20,000 ft and at the high temperatures encountered in this well.

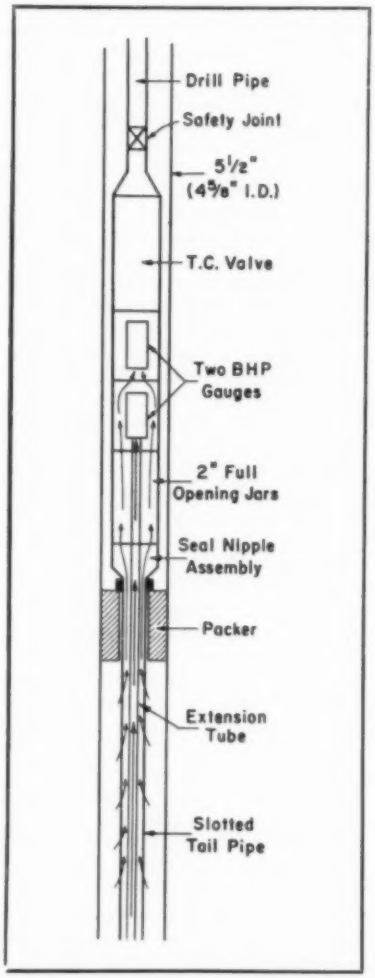

FIG. 10. **Formation testing arrangement to test the entire open hole section below the 5½-in. liner.**

This well also emphasizes the need for improved tools to drill and complete a well under these conditions. For example, logging equipment must be developed which can operate satisfactorily at the higher temperatures. String shot and casing perforating guns also need to be improved to increase their reliability at these greater depths and temperatures. It is important that some means of accurately measuring the deviation of these hot, deep holes be provided. And many problems remain to be overcome in the use of packers and other formation-testing equipment under the conditions found at the bottom of these hot, deep holes.

As a result of this engineering skill and the aid of advanced type of variable density geophysical work recently completed, it is believed that the next projected deep well to be drilled in 1959 on this gigantic dome should result in a successful producer at a lesser depth and at a location that should have lesser temperatures and lower costs.

It is paradoxical to note the fact that this well, the deepest thus far drilled in South Texas, and one of the deepest in the world, was drilled on the ranch of one of the pioneer oil men of Texas, O. W. Killam, deceased, whose colorful career was characterized by the drilling of more shallow wells than any other living person in the State of Texas at the time of his death, January 1, 1959.

Acknowledgment

The author wishes to express appreciation to H. C. Warren, W. L. Ginther, and their associates in connection with the drilling of this project and for their permission to use the information contained therein; and to Dillard-Waltermire, Inc.; contractors; to Dough Evans and Henry Yarborough, superintendents of Dillard-Waltermire; to C. O. Smith, Sr., drilling superintendent and Dr. George C. Clement, chief geologist for Ginther, Warren and Company; to Bill Calohan, consulting geologist, Laredo, Texas; and to all the drilling crews of Dillard-Waltermire and mud engineers of Magcobar for their help and cooperation in connection with the drilling of the Ginther-Killam "A" No. 1 well, with an especially grateful acknowledgment to James H. Courtney, petroleum engineer for Ginther, Warren & Company; James N. McCaskill, Magcobar staff engineer; and Jack W. Williamson, editor of *The Petroleum Engineer* for their assistance in writing this article.

★ ★ ★

Engineered spooling practices can give you . . .

Safety and Savings in Wire Line Spooling

Part 1

Careful attention to job and equipment will help you determine the correct spooling method which will result in fast, safe, and economical wire line operations

Lonnie Thompson,
Lebus International Engineers, Inc.
Longview, Texas

WIRE LINE SPOOLING is a controversial subject due to the many varying factors involved. It many times is a troublesome task or problem, but isn't it true that a problem is half solved when you know the source of the trouble? You are then ready to tackle the problem and find a good solution.

However, certain basic facts pertaining to wire line spooling have been discovered and proved from past operations and development work. Therefore, it is wise to use these proved basic principals to solve any wire line spooling problem.

A hoist is a machine designed to do work by spooling a wire line on a drum to take up or let out the line for manipulating a traveling block and/or lifting hook. If the wire line is not being spooled smoothly and efficiently, the machine is not doing its best work and the hoisting operation is not as safe and economical as it could be.

To obtain good spooling of wire line, proper drum design is very important. However, other rig components must be properly designed and related to each other before good wire line spooling can be achieved. This article will outline some of the problems involved and the best current practice in their solution.

Advantages of Good Spooling

You may ask the question, what are the advantages of good spooling? Due to the fact that an inoperative well is of little use to a producing company and that the job of getting it back on production was usually needed yesterday and should have been anticipated the previous week, the equipment used to get the well back on production is required to work as fast as possible in so doing. This means that the hoisting equipment must be in good working order. But if the line is piling up or cutting in to such an extent that the work is slowed up, a prudent operator will investigate why.

The drilling, workover and well servicing businesses, like most other businesses, are competitive, and because they are service businesses, it behooves any contractor to get the most work done at the least expense possible from his machinery. Costs for equipment and supplies have risen, while for the most part, contract working prices have remained nearly the same. This means that the contractor is working closer than ever to a profit-loss margin. Expendable items particularly, demand close attention and wire lines are an expendable item.

Aside from the economic advantages of proper spooling there remains the important factor of increased safety. Even the safety factor involves economics as it affects insurance rates. However, some practices in use today involve safety risks which are important and foremost in the minds of all good contractors. This is due largely to a practice of hand spooling where it is necessary to place the line properly on a plain drum so that some sort of spooling can be obtained on the upper layers.

Thanks to safety-minded drilling and servicing crews, the breaking of wire line is an infrequent occurrence today, but the constant attention that one must devote to spooling in many cases, makes it a costly item. If this practice of hand spooling can be eliminated, it will remove one very hazardous and often time-consuming job. It is therefore evident that good trouble-free spooling is safer, saves (or makes) important money and saves (or creates) valuable time. What better incentives could there be to stimulate every equipment owner to incorporate good wire line spooling on his equipment.

Many Factors Affect Good Line Spooling

Good wire line spooling is one that operates trouble-free and allows full speed in the hoisting operation. It is without excessive whip in the line due to spooling and with a minimum amount of scrubbing and cutting-in of the line. If this can be obtained, then maximum service can be obtained from the line. Consider the general design factors of a well servicing rig. It must be light and highly portable. It must set up fast and rig down just as quickly. It must be stronger than any load it is required to handle and have as many of the latest time-saving and safety features as practicable. And it must not be too long, too wide, or too high. This is no small order for the designing engineer.

Most users agree, from practical experience, that three sizes of servicing rigs are required to service wells efficiently down to a depth of 14,000 ft . . . one to cover depths from 0 to 5000 ft, another to operate efficiently from 4500 to 8500 ft and a third from 8000 to 14,000 ft. Obviously, it is not economical to use a 12,000-ft capacity rig in servicing a well only 3000 ft deep. However, both manufacturers and contractors are looking forward to a day when new materials, mechanisms and better design will make it possible for only one, or possibly two, rigs to handle efficiently the depth range now requiring three sizes.

Good Spooling Starts with Proper Drum Design

The size and line capacity of a drum for a particular size well servicing unit is largely determined by the maximum load and depth requirements which this rig is designed to service. Allowance must be made, however, for the use of several line sizes to satisfy the different conditions that may exist in different areas. Therefore almost every

Based on paper presented by the author at third annual convention of Association of Oil Well Servicing Contractors, January 15-17, 1959, Dallas, Texas.

drum in its basic design must be made to accommodate at least two sizes of line.

Another factor to keep in mind here is drum and line diameter ratio. Actual ton-mile records prove that for drilling rigs the best ratio economy-wise is 24 to one. Ratios of 20 to 1 or less give a sharp decrease in ton-mile service. All the while the engineer must keep in mind the problem which also affects the drum diameter and width, and the amount of build-up of the line.

Mast Height . . . Brakes

Height of the mast is another important feature in drum design. Here again the size and depth of the well is involved. From the standpoint of spooling, the height of the derrick determines the fleet angle of the line spooling on the drum. This angle will largely determine how well a line can or cannot be spooled and it also affects the service life of the wire line. It must be given consideration in designing the height of the mast.

Another important consideration is brakes. As wells get deeper and loads become heavier, the more important becomes the necessity for good efficient brakes. This has given some trouble that all are aware of, but did you realize it affects design of the hoisting drum as well?

Center of Gravity . . . Weight

The center of gravity is an important feature that affects the size and position of equipment on highly portable rigs. This fact has in some cases complicated the working of the line to a small extent on double drum units making it necessary to use more floating sheaves in order to get in and out of drums to the derrick. This is another factor in the life of the line. A low center of gravity is most important to contractors in mountainous country and mountain roads have done much to create a demand in some areas for the short European manufactured units. This is due more to the length of the American manufactured units than height or center of gravity.

One big factor that varies from state to state is the overall size and weight of the units. This is so critical in some states that it affects the entire design of the equipment. California, for example, has a higher weight law than some states, making it possible to build the units within the portable weight laws. However, weight is so critical that great care has to be taken in the design of the unit.

If length, width and height are not held below maximum limits set by state laws, the well servicing contractor is penalized not only by the cost and limitations of special permits but by the valuable time required to obtain these special permits.

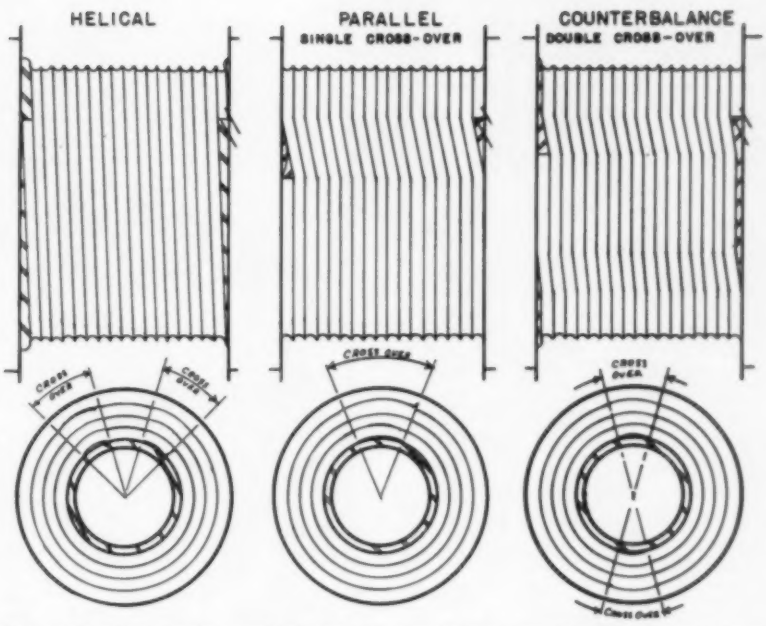

FIG. 1. **Wire line spooling methods** illustrate three basic systems. The helical method, ideal for one layer of line, is not suited for multi-layer spooling since it is impossible to control crossover points when spooling back across the helix. The parallel, single crossover method is suited for spooling two or three layers at moderate speeds. Build-up of line at crossover can cause dangerous vibrations at high loads and speeds. The counterbalance, double crossover method is suited for multi-layer spooling since line build-up occurs at crossover points on opposite sides of the drum, resulting in smooth, counterbalanced spooling.

All these and many more points of consideration are problems of designing engineers in every hoisting unit. We all know that many improvements have been made. So many, in fact, that any unit over five years old is outdated for much of today's work.

Rig Design Affects Everyone

The contractor may well ask, why should I be bothered with all these problems when they belong to the designer of the hoisting equipment? Well, the fact is that all of these features affect the operational cost of the equipment when it is set to work. And today a contractor can ill afford to overlook these facts in selecting equipment where time and operating expenses affect his profits in a highly competitive business. Personal experience has taught that to live long and do well in the oil business, one must know his business and something of the other man's business as well.

Three Basic Spooling Patterns

1. Helical spooling. In this system, initial layer of line progresses across the drum in a helical pattern like a thread on a bolt. (See Fig. 1.) Thus, its name "helical." It is the oldest system in use and where only one layer of line is to be spooled, it is considered the best. It is not satisfactory for multi-layer spooling due to the second and subsequent layers having to spool against the helix. Spooling back across a helix forms a two crossover which occurs in about one-third the circumference of the drum. This creates undue scrubbing on the line and induces vibration of the line spooling off the drum at fast speed which is also undesirable.

2. Parallel — single crossover spooling. In this system, the line spools parallel to the drum flanges and crosses over one diameter where the line enters the drum. This system can be used for multi-layer spooling. However, it has the disadvantage of all the build up of line on one side of the drum due to line crossover at one point on the drum. It also crosses the line over in a short space and must move the line over one diameter each crossover. This has a tendency to vibrate to excess when spooling off the drum at high speeds as well as causing the wire to become unbalanced due to the single crossover and line build up on one side of the drum.

3. Parallel—double crossover spooling. In this system the parallel spooling is divided in two equal sections by two crossover sections at 180 and 360 deg on the drum. Each crossover moves the line over only one-half diameter to accomplish the required crossover of one line diameter for each drum revolution. This accomplishes two improve-

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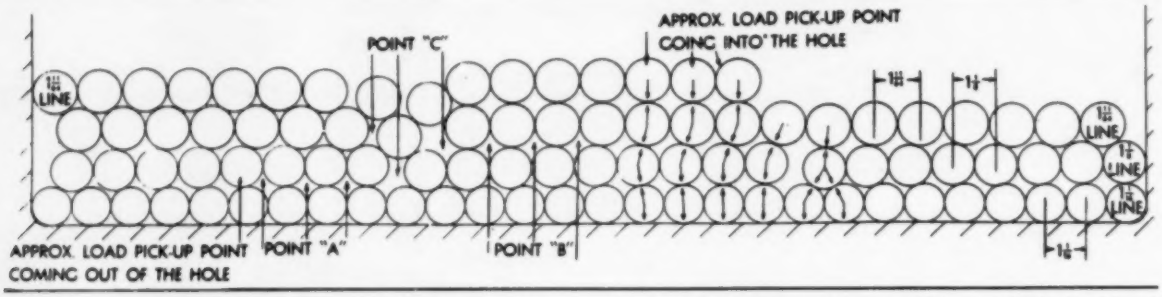

FIG. 2. **Spooling on plain drum** can lead to cutting in, squeezing, and pinching of wire line. Illustration shows a worn, or "pulled down," 1⅛-in. line on a plain drum. The first layer has been pulled down to 1 1/16-in. diameter, the second layer to 1⅛-in., and the third and fourth layers to 1 1/64 in. The larger lines, spooled on top of the smaller lines, cause gaps as at A, B, and C, allowing the line to cut in.

ments; one, the build up of line at the crossover points is smaller than for a single crossover and, two, the line build-up which normally unbalances the drum by being on only one side is now naturally balanced by being spaced at 180 and 360 deg on the drum. The line build up at the two crossover points is less severe because the line crosses the top of only one wrap of line at each crossover. This reduces line wear at the crossover points and allows faster spooling with less line whip. For these reasons, this system is ideal for multi-layer spooling.

Bare Drum Spooling

Bare drum spooling is often referred to as hand spooling because the initial layer must be spooled on by hand. The initial layer then forms the pattern by which all line is spooled on the drum. (See Fig. 2.)

This system requires spooling the line tightly and evenly on the plain drum. Diameter of the line must be such as to come out even between the flanges, and if so it will then spool in a parallel pattern. The system can be expected to spool as long as the initial layer remains fixed and the diameter of the line being spooled in the upper layers is not larger or too much smaller than the line on the bottom layer. With the single crossover, line build up will be on one side of the drum.

There have been times when this unbalancing effect caused the drum to all but walk all over the lease. To prevent this, one must slow down the hoisting operation. Besides being difficult to start correctly, it is often dangerous. But the real problem comes in not being able to change ends of the line to get the service from the other end, due to the unsatisfactory spacing of the worn line on the drum which sets the pattern for spooling layers. There is no easy way to do this job and it is to be avoided if possible.

Grooved Drum Spooling

The functions of a grooved drum are: One, it sets the pattern by which the line is to be spooled (there are three methods . . . helical, parallel, and double crossover); two, it sets the pitch for all the remaining line to be spooled; three, it supports the initial layer of line in a groove deep enough to give support to the line to prevent crushing and flattening. (See Fig. 3.)

The first job is to select the type of spooling needed. If only one layer is to be spooled, the helical pattern will serve well. For multi-layer spooling, 2 to 30 layers, the counterbalance is the best. This is due to the better balancing condition of line on the drum. There is also less movement of the line from its spooling path and it spools the same number of wraps of line for each layer.

The most serious limitation of grooved drum spooling is that only one size line can be spooled on the drum due to its fixed pitch. It is also subjected, of course, to the same fleet angle limitations as any other spooling.

Spooling Swabbing Lines

When a swabbing line is to be installed on a machine, permanent damage can be done to the line if it is pulled around a corner or sill. This can create a spiral condition throughout the length of the line.

The best method of spooling a swabbing line is done with the shipping reel jacked up so that the reel is free to rotate as the line is pulled off. The reel should be placed so that the rope will not pull over any obstacle or obstruction. In some cases, a large block such as a tubing block may be used to keep the rope clean of obstacles. Never use a small snatch block, such as is often carried on an oil field truck, for this purpose. Extreme damage resulting in short rope service is inevitable.

A brake attachment on the reel or a braking device on the reel base will provide enough tension to spool the line tightly on the drum. Braking is imperative to accomplish smooth and tight winding on the pulling unit drum.

Relationship Between Groove Pitch and Line Wear

Let's look at the pitch of the groove. It is important. All well servicing rigs, for example, have relatively light loads so that the groove must be as big as the line when the line is new or nearly so. The ideal situation would be to spool a new line on a grooved drum and use it until the line began to break up, swap ends, and finish it off.

The width of the drum and the number of wraps of line enter into the pic-

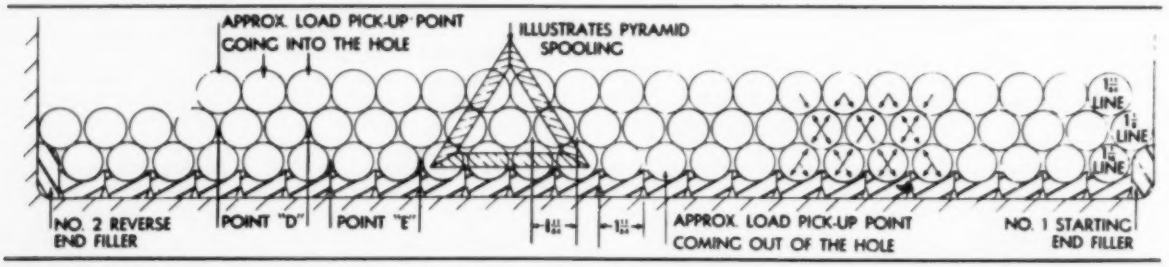

FIG. 3. **Spooling on grooved drum** eliminates cutting in of upper layers into lower, worn layers. The 1⅛-in. line illustrated has been pulled down to 1 1/64-in. diameter, but the grooves hold the line on a definite maximum center so that the larger line is spooled regularly on top of it. Gaps are eliminated and spooling is smooth and even.

ture here. For instance, a 9/16-in. line pulled down only 1/16-in. in diameter will accumulate 2½-in. in 44-in. This is enough space to insert several extra wraps of line. This pull-down of the line on a narrow drum, say 12 to 18 wraps in width, gives very little trouble as the line cannot cut in due to lack of accumulated space on the drum (from line wear). This is important because it means that to get the most service from a small line on a wide drum, the groove has to be as narrow as possible and still accommodate a new line. It has to be the average size of all new lines of its type.

Experience with grooved drums has taught that for any fixed groove pitch, the line will function without trouble up to a reduction of 10 to 15 percent in the diameter of the line. The larger the line, the wider this working variation will be. For 9/16-in. swabbing lines, this means approximately 0.045 in. pull-down in diameter for the line which is ⅔ to ¾ of all the service in the line as it will begin to break up with another 0.020 in. wear. This means that a working program should be used with a grooved drum to obtain the maximum service from the line.

For drilling rigs, a good cut-off program will do the job. A program for wire line cutting-off has been worked out for rod and tubing drums by using a shorter working barrel with more storage area and making dead-end cuts. This is satisfactory where the unit does not run a double line to speed up pulling rods. But for sand and swabbing lines, none of these procedures will work.

The ideal situation would be to use all the line on each job to get even wear on the line. This is not possible as the average depth of wells swabbed is 5900 ft and most units store 9000 to 15,000 ft of 9/16-in. rope. So, 3000 to 6000 ft of line get no service when first put to work. It is then wise to change ends of the line and use it. This is easy to accomplish if the drum is grooved and the line is not too badly worn before changing ends as the groove spaces the old wire rope to spool the new line.

A program to use this procedure can be set up. If a plain drum is in use, it is difficult to spool the good line trouble-free on top of the old end which is now placed first on the drum. Hand spacing of a worn line on the drum to obtain good spooling is timely and costly.

Another feature about the pitch of grooved drums that is not common knowledge is that different spooling applications require different pitch in order to obtain the best service from the wire line. Many times it is possible to make the pitch small for the line in order to allow more working variation for the line. The drilling rig is such an example. On a slow-moving industrial hoist operating at much lighter loads, a pitch to the full size of the line is necessary. Therefore, the type of the hoisting job, the size and width of the drum, the hoisting load or tension of the load, and the speed of the operation are all factors that determine the correct pitch of the groove.

Part 2 Continued Next Month.

P 500.1

DEVELOPMENTS IN NATURAL GAS RESERVOIR ENGINEERING

Gas production engineering problems still lie in mathematics of gas flow through porous media. Use of finite difference math and digital computing techniques provides answers for specific problems . . . but a complete partial differential equation explaining true flow phenomena has not yet been offered

M. R. Tek, *Assistant Professor, Department of Chemical Engineering University of Michigan, Ann Arbor, Michigan*

ACCORDING to statistics recently given by the American Gas Association, the proved reserves of natural gas have recently climbed to an all-time record of approximately 247 trillion cu ft. The total net production of gas during 1957 was 11.5 trillion cu ft. Ten years ago, the estimated proved reserves were 165.9 trillion cu ft.

Discovery and development of vast natural gas fields throughout the recent years have resulted in upward revision of gas reserve estimates on one hand and in increased consumption of natural gas through domestic and industrial sinks on the other. The current high and still increasing costs of exploration, drilling, well completion, pipelining, processing and distribution of natural gas, points everyday to urgent needs for more accurate, more fundamental, more exacting methods in natural gas production technology.

In the face of higher costs in practically every phase of production operations, the delivery of contract amounts of natural gas to pipelines with minimum amount of cost to the producing company is causing the natural gas engineers to turn to the research engineer for better formulas, better correlations, better predictions and above all for better and more fundamental understanding of flow of natural gas through porous media.

During the last decade, many recognized the tremendous potential of natural gas and its due place in the country's economy. This resulted in the deployment of unprecedented research manpower and resources to the studies of natural gas flow. Much has been accomplished. Through the use and development of new concepts and the new application of old concepts, through the use of more mathematics and less empiricism and through the use of powerful computing equipment,

a good many basic problems have been solved.

Quite unlike oil reservoir engineering, however, the current state of knowledge in natural gas flow through reservoirs is still in the area of transition between art and science. It still remains a bit closer to the art than the science.

One of the major reasons why the problems of natural gas production engineering are far less understood than most problems of oil production lies in the more complex mathematics which apply to the mechanics of gas flow through porous media. The nonlinear partial differential equation describing the flow of natural gas still defies the most advanced mathematical techniques available for an analytical solution. The use of finite difference mathematics and digital computing techniques does provide numerical answers for specific problems but, of course, in by-passing the analytical route, fails to give an insight on the mechanics of the flow phenomena. On the other hand, Darcy's law which is tacitly implied in the partial differential equation, quite often, falls far short of fully describing the microscopic pressure drop-flow rate relations throughout the pore matrix.

A presentation to the operating natural gas reservoir engineer of what has been accomplished in recent years to study and learn about the flow of natural gas, what has been solved, what remains to be solved, and to provide a guide to direct him to the highlights of the available literature have been the major objectives of this article.

MECHANICS OF GAS FLOW THROUGH POROUS MEDIA

Partial Differential Equation

The flow of natural gas through a porous medium is determined by the physical properties of the reservoir rock, the extent and geometry of the drainage area, the properties of the flowing fluid and the conditions of pressure distribution within the porous matrix.

The partial differential equation describing the flow of natural gas through porous media is given in many references:[1,2,3]

$$\Delta^2 p^2 = \frac{2\phi\mu}{K}\frac{\delta p}{\delta\theta} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Equation 1 above is derived by combining the equation of continuity,

$$\Delta(\gamma\vec{v}) = -\phi\frac{\delta\gamma}{\delta\theta} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

the perfect gas law,

$$\gamma = \frac{p}{RT} \quad . \quad . \quad . \quad (3)$$

and Darcy's law

$$\vec{v} = -\frac{K}{\mu}\text{Grad}\,(p) \quad . \quad . \quad . \quad (4)$$

Equation 1 above is not only nonlinear with respect to its dependent variable p, but also through the pressure dependent viscosity of the natural gas. Except a particularly simplified case of one dimensional[4] flow no general analytical method has thus far been offered for the solution of the above equation. The only analytical solution[4] published for the one dimensional flow model was obtained by R. E. Kidder through the application of a perturbation technique. The extension of Kidder's work to more than one space dimension has not been possible to date. The mathematical difficulties stemming from the non-linearity of the partial differential equation forced many researchers to invest their efforts in numerical, approximate, linearized, graphical or analog solutions. Several approximate solutions have been proposed[5,6,7] but each of these are of limited value and scope due to the associated simplifying assumptions.

In 1952 C. R. Roberts[7] presented a modified analytical solution on the one dimensional and radial unsteady state model. Green and Wilts[8] simulated the one dimensional, constant terminal rate gas flow problem on an electrical network. The paper by Green and Wilts was followed by several publications based on numerical solutions[2,9,10,11,12,13,14,15] of finite difference equations corresponding to Equation 1 above. These solutions were obtained by digital simulation on electronic computers.

In the area of approximate idealized and linearized solutions radial gas flow equations were suggested by Elenbaas and Katz[16] and by McRoberts.[17] A graphical solution to the linearized partial differential equation was offered by Cornell and Katz[18] who applied the classical Schmidt-heat transfer-method technique to gas flow, boundary value problems. In the area of analog simulation the unsteady radial flow of gas through a porous matrix was studied experimentally and theoretically by A. Houpeurt.[19] Houpeurt's work was later extended by Rene Iffly.[20]

Darcy's Law — Engineering Applications

The relation between the quantity of gas delivered and the pressure drop within the reservoir is characteristic of the behavior of each well. This relation is often referred to as the back pressure behavior of the well.[19,21,22,23,24,25] These studies have established beyond a reasonable doubt that for normal single phase gas wells the relation between the gas delivery rates and the bottom-hole pressures take, in general, the following form:[25]

$$Q = C_p\,(P_s^2 - P_f^2)^n \quad . \quad . \quad . \quad . \quad (5)$$

where n is invariably found to be between 0.5 and 1.0.

When the slope of the back pressure curve, n, is equal to unity the formation is considered to be producing according to Darcy's law. In fact when differential Equation 1 is integrated for the steady state flow condition, the resulting pressure distribution may readily be used to derive a flow rate pressure drop relation quite identical to Equation 5 with $n = 1.0$. On the other hand when n is less than 1.0, it is well recognized that the solution of the partial differential equation does not converge, in the steady state, to the well observed back pressure behavior indicated by the Equation 5. This is true of all numerical solutions of Equation 1 obtained by digital computers.

Nomenclature

- p – absolute pressure
- γ – mol density
- Δ^2 – Laplacian Operator; $\Delta^2 = \frac{\delta^2}{\delta x^2} + \frac{\delta^2}{\delta y^2} + \frac{\delta^2}{\delta z^2}$ in cartesian coordinates
- ϕ – porosity
- μ – viscosity
- K – permeability
- θ – time
- $\Delta(\gamma\vec{v})$ – divergence; $\Delta(\gamma\vec{v}) = \frac{\delta}{\delta x}(\gamma v_x) + \frac{\delta}{\delta y}(\gamma v_y) + \frac{\delta}{\delta z}(\gamma v_z)$
- R – gas constant
- T – absolute temperature
- $\vec{v}$ – velocity vector
- Grad (p) – pressure gradient; in the x direction $\text{Grad}\,(p) = \frac{\delta p}{\delta x}$
- Q – standard gas production rate
- C_p – the performance coefficient
- P_s – static reservoir pressure
- P_f – flowing bottom hole pressure
- n – slope of the back pressure curve

Since the partial differential Equation 1 is but a combination of the equations of continuity, state and the Darcy's law, the logic suggests that either or both the thermodynamic equation of state and the Darcy's law could be the sources of the discrepancy. The pressure dependent compressibility factor certainly adds to the nonlinearity of the problem,[26] but its effect on the overall behavior is not considered to fully explain the observed back pressure phenomena.

The incapability of Darcy's law to fully explain the flow phenomena at high rates was recognized by many for a long time.[27, 28, 29] It is well known[30] that, as the Reynolds number, characteristic of the fluid flow through porous media, becomes large, Darcy's law gradually loses its predictive accuracy and ultimately becomes completely void. For the last 20 years, much has been said and written on this subject.[31, 32, 33, 34, 35, 36]

To some,[31] a mechanistic analogy with pipe flow proved a satisfactory explanation of the deviation from Darcy's law.

To others[27] turbulence, in its random character, was incompatible with the geometric structure of porous systems. While the subject remained controversial for many years, the development of vast natural gas reserves throughout the recent years further justified considerable interest in this problem from the viewpoint of gas reservoir behavior. As large amounts of field data became available from the operation of many gas fields, it became more and more evident that the observed steady state behavior of gas wells was not, in general, in agreement or compatible with Darcy's law. This suggested a careful study of all possible mechanisms which may account for pressure drops in addition to viscous shear.

During 1953, in a series of papers,[19] A. Houpeurt demonstrated that irreversible kinetic energy exchange between the flowing gas and the surroundings and some orifice flow phenomena continuously taking place in the inter-pore geometry would cause the flow rate to be proportional to the difference between the squares of upstream and downstream pressures elevated to a decimal power, between 1.0 and 0.5.

Houpeurt's theory has been experimentally verified, extended and theoretically reinvestigated by R. Iffly.[20] His mathematical analysis carried through the micro-pore geometry and extended through the macro-reservoir scale resulted in the generalization of Darcy's law, in the dimensionless form by M. R. Tek.[30]

Before this work was in progress in the United States, another paper by G. Schneebeli[37] indicated that special experiments in continental Europe by Lindquist clearly demonstrated that the onset of turbulence within a porous medium does not necessarily coincide with the conditions of deviation from Darcy's law.

A theoretical and statistical evaluation of the conclusions advanced by A. Houpeurt, practical applications developed to reduce the theory into a directly useful engineering practice has been published during 1955 by Tek, et al.[25]

FURTHER INVESTIGATION

An evaluation of recent developments in natural gas reservoir engineering research indicates that during the last decade much has been accomplished. Yet it is easy to see that a lot remains to be further investigated.

The problem of the unsteady state flow of natural gas through porous media is at best only approximately and numerically solved. It applies to a very idealized mathematical model.

A complete partial differential equation describing the true flow phenomena and based upon non-restricting, generalized laws has not yet been offered. In the area of direct reservoir engineering applications, no method is yet available to predict the slope of the back pressure curve of a gas well. Calculation methods available for the determination of effective drainage area permeabilities, performance coefficients, drainage radii, interference effects, static reservoir pressures are perhaps satisfactory for our current engineering requirements but are all rough approximations and can certainly stand substantial improvements in their predictive accuracy.

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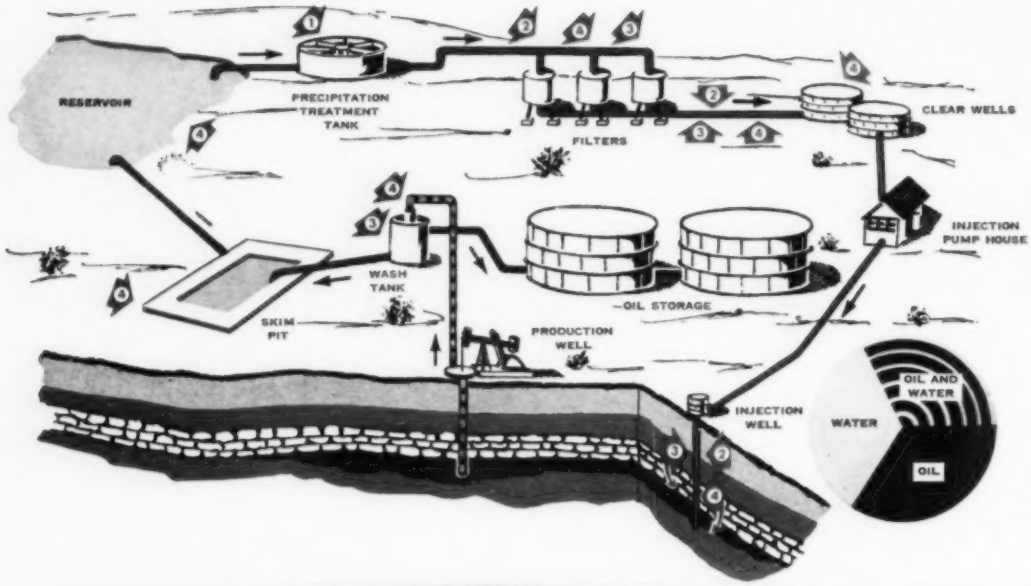

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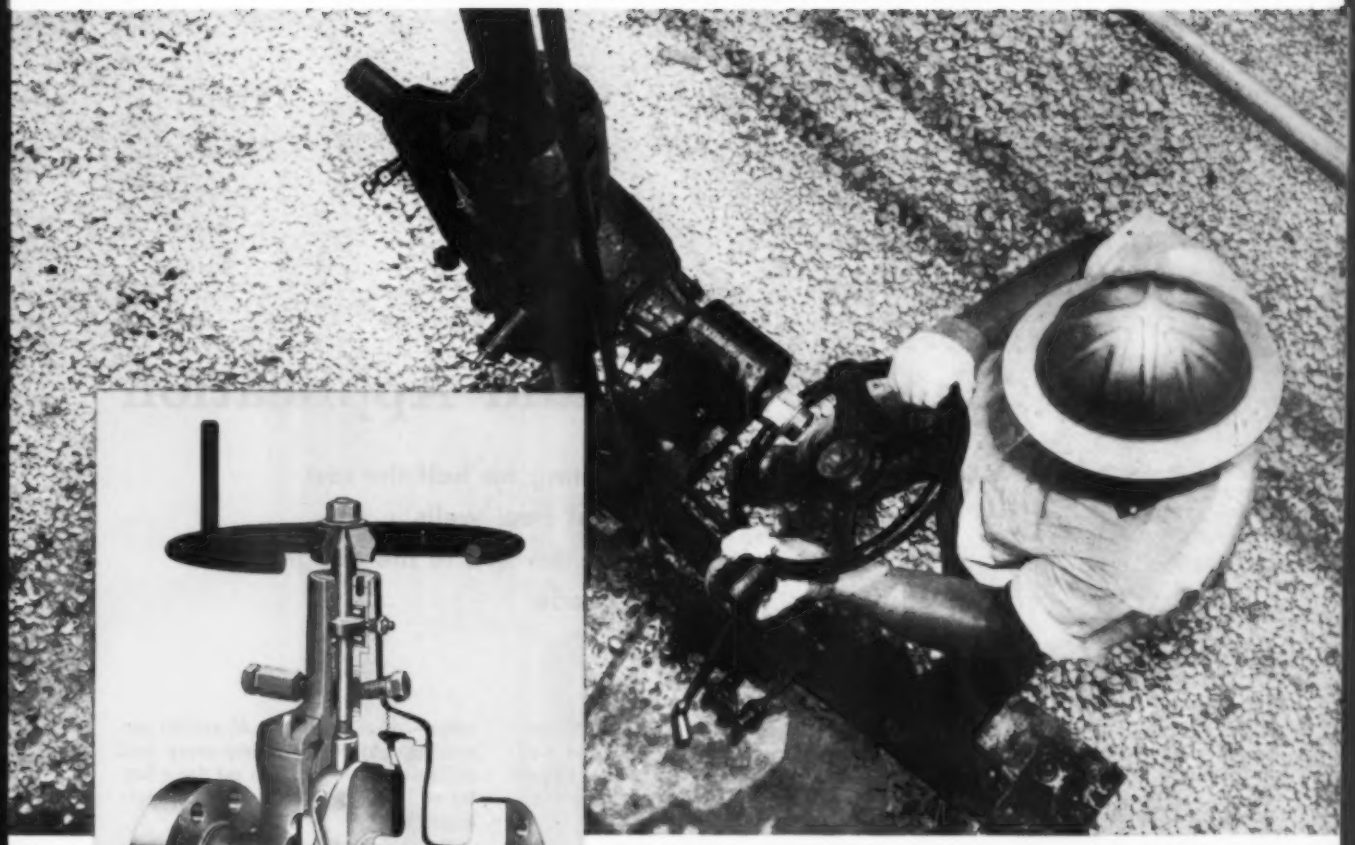

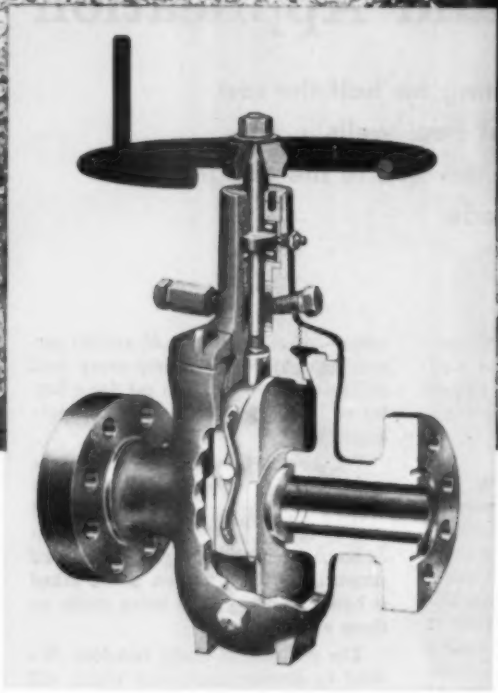

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THE ATLANTIC LECTURES OF THE UNIVERSITY OF TEXAS

PART 5

TUBULAR PRODUCTS: Their Design and Application

With casing and tubing accounting for half the cost of drilling and completing most new wells, much effort and talent must be devoted to the design and application of tubular goods

S. H. Davis, *Senior Production Engineer*
Atlantic Refining Company, Dallas, Texas

THE DOMESTIC OIL INDUSTRY is faced today with the greatest challenge in its history. More in particular the engineer himself is faced with this challenge. Much has been said about the equipment required to drill and complete the deep high-pressure wells. But the real challenge is completing these wells at a cost that will make the deeper reserves economically exploitable. It is one thing to engineer equipment capable of doing the job at the greater depths, but it is another thing to make it a profitable operation.

One might ask, "Hasn't the engineer always been faced with this challenge?" The answer is yes, but only to a limited degree.

For an extreme example, let's compare the oil producing business of Spindletop days with those of today. I recall having seen an old newspaper clipping and photographs advertising the stock issue of the "Lucky Dime Oil Company" at Spindletop. The fact that the stock was 10 cents a share is interesting in itself. But what really pointed up the contrast was the production rate of the wells and the lack of conservation. The advertisement stated that the well was capable of producing 6000 to 8000 bbl of oil per day. Imagine 8000 bbl a day from a depth of 1100 ft! All those interested were being invited to go by the well site to see the well flow. In the accompanying photo was shown a man with his hand on what appeared to be a 6-in. valve and out of this valve was flowing a 6-in. diameter stream of oil. It wasn't flowing into a tank, but on the ground.

Who couldn't engineer a profit into an 8000 bbl a day well only 1100 ft deep! If the oil sold for only $0.25 a bbl and the well cost $8000 to drill, it would pay out in four days. A 50 percent increase in the cost of the well would take only two more days to pay out. Therefore, who needed engineers to make a profit.

Economics and Engineering

Now, contrast this with the present day situation. An average 10,000-ft well in the Gulf Coast might be completed for $140,000. It would be a fairly good well if we could get a 200 bbl per day allowable. The payout at $3 per bbl would be 233 producing days. At 10 producing days a month the drilling and producing costs would pay out in two years. Exploration and leasing costs would still not be paid out. Just a 10 percent increase in cost will require an additional two months to pay out. A 10 percent increase in cost would have been payed out in only *one* day at Spindletop.

This points up one highly important factor: Real engineering isn't done until economics are involved. Where cost is not a problem, each of us with very little thought can arrive at a satisfactory solution to a problem.

Now where do tubular products fit into the economic picture of drilling a well? There are those who might tell you that casing and tubing are just routine items which are run in a well after the well has been drilled. Let's put things in their proper perspective for a moment and see if casing and tubing are just routine. Atlantic finished drilling a well a few months ago for which the casing and tubing costs were $400,000. The total well cost was approximately $750,000, so the casing and tubing made up 53 percent of the total cost. Not so routine in my books. An analysis will reveal that casing and tubing make up between 40 and 60 percent of the cost of nearly every well drilled today. Could you ask for a better or more important place to apply engineering talent?

We are constantly bombarded by the spectacular . . . world's depth record broken . . . world's longest string of 9⅝-in. casing run! These are important of course, but let's not get them out of proportion. The question to be asked is how much money is being made on these ventures.

The problem is really two-fold. We need to develop equipment which will permit us to drill deep high-pressure exploratory wells — this of course comes first. This first step, however, is of very little lasting value unless we can economically develop reserves when they are found. Therefore, more engineering talent must be devoted to the application of the casing and tubing materials we already have.

Of what advantage is it if the drilling engineer can auger down a hole 20,000 ft deep if the cost of high-strength tubular products for completion makes the venture unprofitable? One major company is reported to have made a study which indicated that all of its recent ventures below 10,000 ft when taken as a group showed a very poor return for the investment. Since any new domestic producing horizons will likely be below 10,000 ft, we must make these operations profitable. It's as simple as that.

The challenge of making the deeper reservoirs economically exploitable has a real significance to the engineer given the responsibility of developing casing and tubing programs. Being responsible for the engineering on about 50

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percent of the well cost makes him a highly important figure.

First, let us refresh our thinking as to what we mean when we refer to casing and tubing. In this era of slim-hole drilling, what is tubing today may be casing tomorrow. Generally speaking, however, tubing runs from ¾ in. to 4 in. nominal and casing covers 4½ in. through 20 in. OD.

Fig. 1 is a sketch showing a typical casing and tubing installation. Surface, intermediate, and production casing are shown cemented in place. Also there is a packer on the lower end of the tubing string. The production will enter the production casing through the perforated interval and be conducted to the surface inside the tubing.

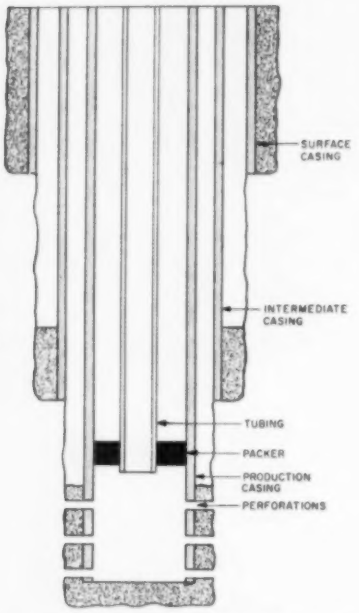

FIG. 1. Typical casing and tubing installation shows three strings of casing cemented in place and a tubing string with packer attached above the perforations in the production casing.

Casing has the function of holding back and protecting the subsurface formations penetrated. Tubing is run inside the casing to conduct the produced fluids to the surface. You might ask, "Well why not produce through the casing!" There are several answers, but briefly, tubing provides a means of well control. It also prevents the well fluids from contacting the casing where a leak might allow high-pressure fluids to cause a blowout or to enter unprotected formations behind the casing.

Tension and Collapse Forces

Before we can get into the subject of design and design factors, we need to have some understanding of the forces which are actually exerted on casing and tubing. The forces normally considered are tension, collapse, and burst. Tension is caused primarily by the weight of the casing and tubing. Therefore, tension is maximum at the top and zero at the bottom. The collapsing force is exerted by the hydrostatic head of mud or by formation pressure acting on the outside of casing and tubing.

Maximum collapsing force occurs when the casing or tubing is empty. Back in the early thirties no one was concerned with casing collapse since wells weren't deep enough for collapse to be a problem. As the wells got deeper in the late thirties and early forties collapse became a real problem. Considerable concentrated effort was put forth at that time to determine what collapse strength the various sizes of casing possessed. Because of this effort and because of the API organization, we now have published collapse strengths.

When internal pressure is applied to casing at the surface, location of the point of maximum burst pressure depends upon the relative densities of the fluids inside and outside the casing. If the densities are equal the burst pressure will be uniform from top to bottom. If the density of the fluid outside is greater, the point of maximum burst pressure will be at the surface. Finally, if the density inside the casing is greater, the point of maximum burst pressure will be located down the hole. We at Atlantic believe that the latter condition exists in most wells sometime after completion. That is, a salt-water gradient will exist outside the casing and a heavier mud exists inside.

Fig. 2 represents a 12,000 ft Gulf Coast well. As is typical of the area and depth, the formation pressure is equal to a gradient of 0.80 psi per ft, giving a bottom-hole pressure of 9600 psi. Normally the mud gradient required to drill this zone would be 0.81 psi per ft. Assuming that the well is a gas well, its shut-in tubing pressure would be 0.80 of the bottom-hole pressure, or about 7700 psi. The key to the understanding of this concept is to recognize that some of the zones penetrated at 6000 to 8000 ft may only have an 0.50 psi per ft bottom-hole pressure gradient.

Now what happens if there is a tubing leak near the surface? The 7700 psi is exerted on the casing at the surface.

But what is the condition at 8000 ft? The mud column will exert a pressure of 0.81 times 8000 or 6480 psi at 8000 ft. In addition, the 7700 psi tubing pressure acts downward on the surface of the mud. The result is 14,180 psi inside the casing at 8000 ft. Outside, the pressure is 8000 times 0.50 or 4000 psi. The differential tending to burst the casing at 8000 ft is then 14,180 minus 4000 or 10,180 psi. The differential burst pressure at the surface is only 7700 psi.

In summary, the tension force is maximum at the top, the collapsing force is maximum at the bottom. The point of maximum burst pressure, however, will depend upon the relative densities of the fluids inside and outside the casing.

Tension Design Factors

Now let's turn to casing design and design factors. Engineers who have preceded us made great progress. But it is quite difficult and often very costly to get usable data from two miles beneath the surface of the earth. Every-

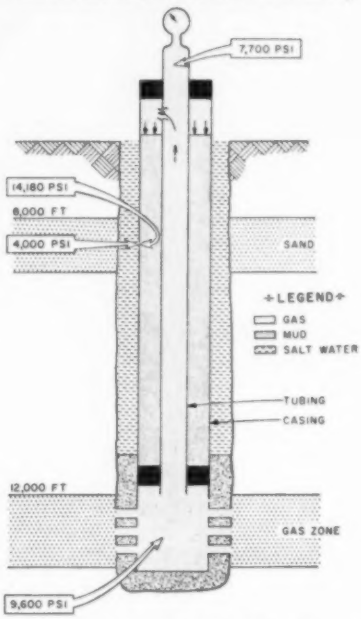

FIG. 2. Example of 12,000 ft Gulf Coast well shows pressures typically encountered in this area and their resulting forces on casing and tubing.

one uses combination casing designs; we take into account biaxial or combined stresses, and we occasionally have lowered our design factors.

For years it has been common practice to use a 1.6 to 1.8 tension design factor based on the weight of the casing in air. This means that the effect of buoyancy has been neglected. In effect it means that the actual design factor varies with the mud weight. Atlantic engineers came up with the idea several years ago of actually incorporating buoyancy into their design charts. This gives us a constant effective design factor of 2.0 regardless of mud weight.

In comparison, we are using an "air design factor" of 1.5 to 1.7, depending on the mud weight, as compared to the 1.8 mentioned previously. So what ap-

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peared to be a more conservative position is actually a further advancement to more liberal design factors. Fig. 7 shows a quick design chart for 7-in. casing and 12 lb per gal mud. Charts of this type are universally used in the industry. Their use eliminates individual calculations for each casing string.

The design factor in tension provides protection against impact loads encountered while running casing. This type loading occurs when the downward motion of the casing is stopped abruptly or when the casing suddenly falls through a bridge in the hole. Since a design factor of 2.0 is just about the minimum requirement for impact loading, I doubt if engineers will be able to make a significant reduction in the tension design factor.

There is, however, still a need for better application of high strength casing joints in our designs. For instance the API long thread and coupling joint is only 70 to 80 percent efficient. This means that we have 20 percent more strength in the pipe body than we are actually using. Therefore, the engineer is charged with the responsibility of evaluating existing high strength joints and with developing new ones.

It might be well to consider why we have design factors, or safety factors, as they are often referred to. In many respects we can liken it to insurance. The more things we have wrong with us or the more hazardous our occupation, the more life insurance we take out. The same is true of casing and tubing. The more defects we expect and the greater risk, the higher the safety factor the engineer uses. Now the same is true of design factors as is true of life insurance, the higher their value, the greater the premium we must pay!

Collapse Design Factors

Casing is most often designed on a tension-collapse basis and then checked for burst. We have already looked at tension design factors so let's look at collapse design factors. Here again there is a degree of disagreement among engineers. The most universally used factor is 1.125, but the basis varies. Some engineers assume that only a salt water gradient is acting outside the casing. This is more than likely correct after the mud column has deteriorated and the formation pressures have decreased.

On the other hand we have known of casing designed on this basis to collapse from formation pressure when the well was swabbed down to the packer during a test. So we prefer to base our 1.125 on the mud weight at the time casing is run because the mud weight is indicative of the actual pressure of the producing zone and adjacent formations.

There is one phase of collapse design which deserves considerable future attention; that is, intermediate casing string design. An intermediate or protective string renders its service primarily during the drilling operation and in many respects is useless after the oil string has been run. The intermediate string is not likely to be empty of mud during its useful life. You will see the possibility that we might be able to reduce the collapse design factor for intermediate strings. A few engineers have lowered their design factors to 0.50 in collapse for intermediate strings. In working out a series of intermediate casing quick design charts which are based on this concept, it appears that the savings to be realized in their use will range from $2000 to $30,000, depending on the length of string involved.

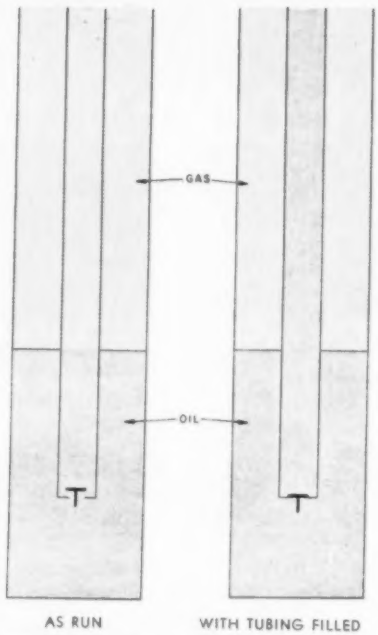

FIG. 3. **Schematic drawing of pumping well illustrates the increase in tubing tension resulting from weight of oil column on the standing valve.**

Most engineers prefer to have a casing design factor of 1.0 to 1.3 in burst. Again the basis varies. We assume, as shown in the burst example, that a saltwater gradient is present outside the casing which acts to resist internal casing pressure. Others assume a mud gradient is acting outside the casing. Still others assume that no outside pressure is present and that the burst pressure is equal to the full internal pressure. The proper choice will depend upon the specific conditions.

Tubing Design Factors

Tubing has a different function than casing; therefore, we are forced to consider its design and design factors in a different light. For instance casing is run and cemented in place and is not designed to be pulled and rerun a number of times as is tubing. Tubing is run and pulled a great many times in the life of a well. Sometimes during these pulling operations a packer will stick and it becomes necessary to raise the tension in the tubing to a value considerably above that due to its weight. Tension will increase also during normal pumping operations when the weight of the oil column is on the standing valve (see Fig. 3). To allow for this increased tension the design factor is normally greater than that used for casing. In most instances, however, we examine the operating conditions in arriving at our tension design factor for tubing strings.

One of the tubing's main functions is to conduct fluids to the surface without permitting well pressure to reach the casing. In this sense, tubing is actually a working string exposed to the pressure and corrosive action of well fluids. We at Atlantic believe that our tubing should have a 1.5 to 1.7 design factor in burst. Our concept is to keep the pressure in the tubing. In collapse we treat tubing the same as casing, assuming that the tubing is empty and that the mud head is acting outside.

In covering design and design factors, I don't want to convey the impression that all oil companies should immediately reduce design factors or, for that matter, adopt the same design factors. An engineer must have a thorough knowledge and understanding of how forces act on casing and tubing as well as a background of experience before he can attempt to alter design factors. Without this thorough knowledge, he may overlook the one factor which will spell failure for his design!

What can the engineer do to reduce design factors? We said we needed these factors as insurance against defects and because of the risks involved if we had a failure. To reduce the design factors then, we either must eliminate as many defects as possible so we can be sure of our strength properties, or we must appraise the risk and decide whether or not we can afford to take it.

Design and Manufacture Of Tubular Goods

During the days of the East Texas boom, casing and tubing products were nearly in a state of hopeless confusion. There were no standards cov-

ering sizes, tolerances, wall thickness or thread forms. There was no guarantee that casing from one mill would make up with casing from another mill — in fact it was almost a sure bet that it wouldn't.

Since that time, however, largely through the efforts of the many companies working through API standardization committees, a high degree of order has been established in the field of tubular products. This includes casing, tubing, drill pipe and line pipe. API specifications cover weight, wall thickness, grade (strength), manufacturing tolerances and performance properties. These specifications have been agreed upon by both users and manufacturers.

The API standards do not define or limit the processes by which pipe should be manufactured, but merely set forth the standards which must be met by the final products. Casing and tubing are manufactured by the seamless process and by electric welding.

You can visualize how varied are the requirements of the oil industry with respect to casing and tubing. We can't afford to pay for pipe which is capable of being run in wells 10,000 ft deep when our well is only 3000 ft deep. So, we need materials which will economically fulfill the requirements of both deep and shallow wells. The API specifications meet these requirements by providing five different grades or strengths of material. Table 1 shows these five grades and their minimum properties as specified in API Standard 5A.

Grade designations run from F-25 to P-110, the number referring to the minimum yield strength. Actually we are already using 150,000 psi yield materials, but no standard specifications have been set up. The P-110 grade is still only a tentative standard. You will note that an average yield and the tensile (ultimate) strength are also specified. The percent elongation is nothing more than a measure of ductility.

These values of yield and ultimate strength can be converted into usable values which will tell how much pressure a piece of pipe can stand. Barlow's formula relates internal pipe pressure to stress. By inserting the yield strength and pipe dimensions into this formula we can get the burst rating of a piece of pipe.

Collapse strength is not quite so easy to derive as no one has been able to devise a theoretical equation which will fit all conditions. As a result there are several empirical approaches which are used. These approaches are based on a series of actual collapse tests. Where experimental tests are involved there must be a human interpretation

TABLE 1. Mechanical properties.

Grade	F-25	H-40	J-55	N-80	P-110
Yield Strength (Min.) (P.S.I.)	25,000	40,000	55,000	80,000	110,000
Yield Strength (Avg.) (P.S.I.)	——	50,000	65,000	85,000	123,000
Tensile Strength (Min.) (P.S.I.)	40,000	60,000	75,000	100,000	125,000
% Elongation in 2 in. (Min.)					
Strip Specimens	40	27	20	16	15
Full Section Specimens	45	32	25	18	17

TABLE 2. Minimum performance properties of casing.

1 O.D. In.	2 Nom. Wgt. Lb./Ft.	3 Grade	4 Wall Thk. In.	5 I.D. In.	6 O.D. Of C'pl'g	7 Collapse Resist. P.S.I.	8 Int. Yield Press P.S.I.	9 Jt. Str'gth 1,000 Lb.
7	26.00	J-55	0.362	6.276	7.656	4,060	4,980	395
7	26.00	N-80	0.362	6.276	7.656	5,320	7,240	460
7	26.00	P-110	0.362	6.276	7.656	7,220	9,960	602

and some of the experts still aren't in agreement as to which empirical formula best agrees with experimental results. Actually, the subject of collapse of tubes is quite fascinating and is a field in need of further clarification.

Tension strength of casing joints is also based on experimental tests. There is, of course, no equation which will give the strength of all casing joints. Equations have been set up for determining the strength of API casing joints. These equations are based on experimental results also.

Even though there is need for further refinement in arriving at casing and tubing performance properties, the industry has agreed on a set of performance properties for casing and tubing. This was a necessity to avoid confusion, the same as was the necessity for establishing standard sizes. These values can be found in API bulletin 5C2. Table 2 which has been taken from this bulletin shows the performance properties for 7-in., 26-lb casing. This table shows how the collapse resistance, burst rating and joint strength increase as the material strength increases from J-55 to P-110. Note that the dimensions are constant.

These performance values are not absolute values; they are guaranteed minimums. They are values which the mill says they won't go below even though their material strength and wall thicknesses reach minimum values. Because the mill must aim for values above the minimum, most tubular products will have strengths above the minimum.

Tolerances

Maybe a little tightening of tolerances would give us improved casing and tubing at very little extra cost. Most of the minimum values were established nearly 20 years ago. It might be that improvements in manufacturing processes already inaugurated could permit the minimums to be raised some amount. This is basically a mill problem, but one thing is certain — the mills won't change unless the oil companies can sell them on the idea. Of course, some high strength materials can be "too strong." These materials become sensitive to brittle failure when their hardness and their yield strength are too high. For this reason operators have found it necessary to specify an upper as well as a lower limit on yield strength when purchasing casing and tubing for high-pressure completions. In many instances upper limits are placed on the Rockwell hardness number.

Inspection and Defects

The inside of a modern seamless pipe mill is a pretty impressive sight with all of its automatic machinery. A hot billet of steel starts through a set

Sid Davis *was born and educated in the state of Ohio, graduating from the Ohio State University in 1949 with a bachelor degree in mechanical engineering. While at the university, he was a member of Tau Beta Pi and Pi Tau Sigma.*

Upon graduation, he went to work for The Atlantic Refining Company in their Production Research Department in Dallas. He was assigned to the Well Mechanic's Group, where he worked on projects involving drilling fluids, well completions and drilling rates.

In 1954 he transferred to the Production Engineering Staff Group, also located in Dallas. At the present time, he is still associated with this group and is concerned with well completion and remedial problems. The field of oil well tubular products is one of the several more important responsibilities of this position.

At the present time he is a member of the AIME, the API, as well as several industry committees.

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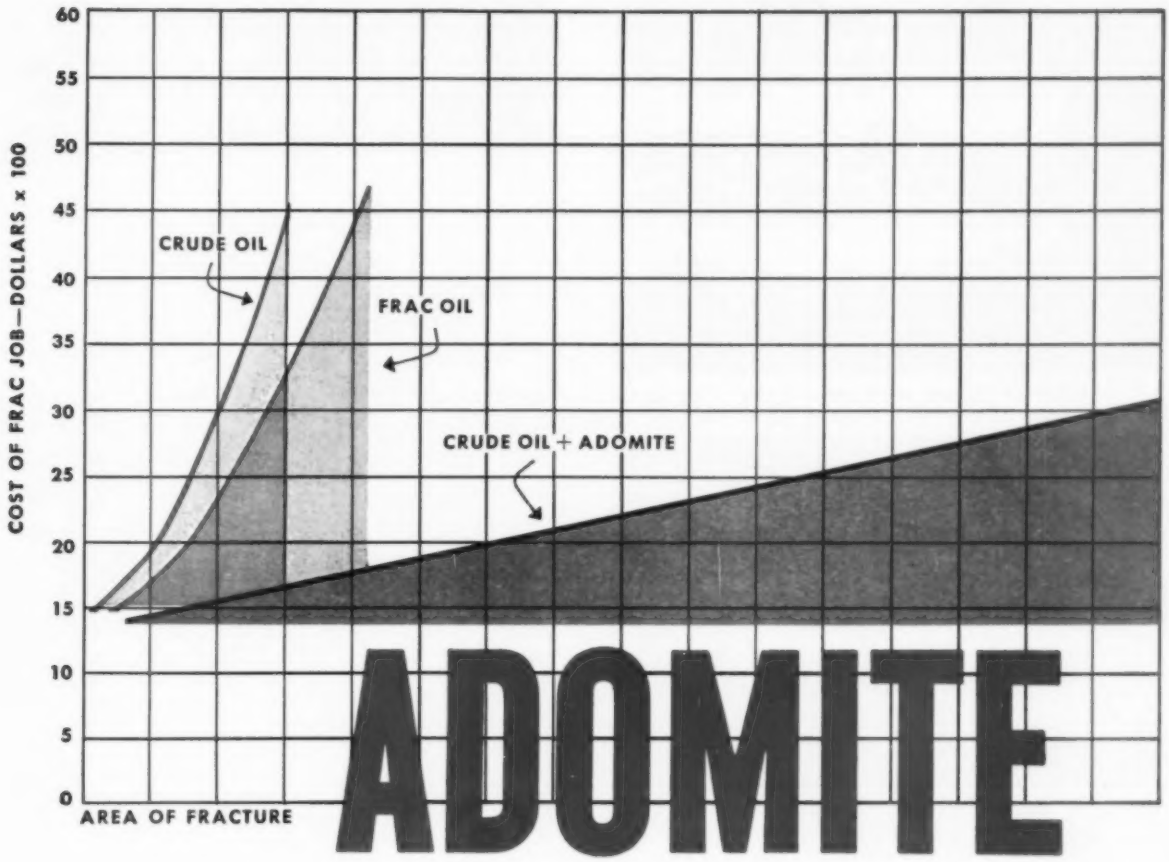

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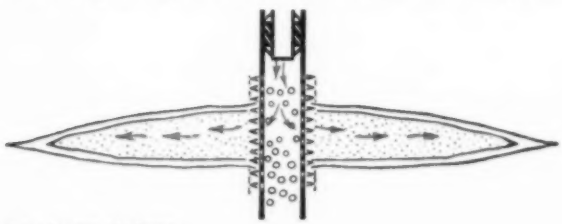

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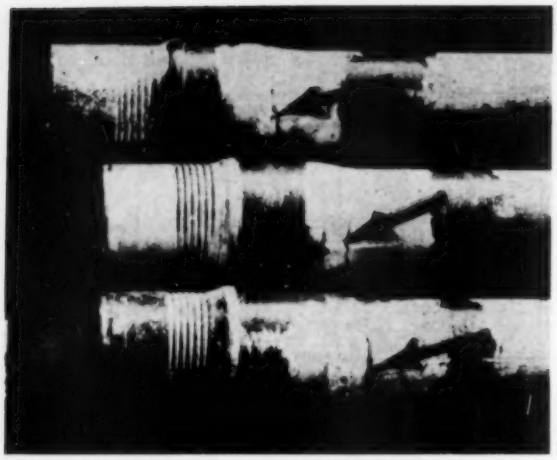

FIG. 4. **Defects on tubing upsets** become visible when pipe is placed in magnetic field and sprinkled with powdered iron.

FIG. 6. **Mill slug defect** results when a piece of cold steel or slag is rolled into the surface of hot pipe during manufacture.

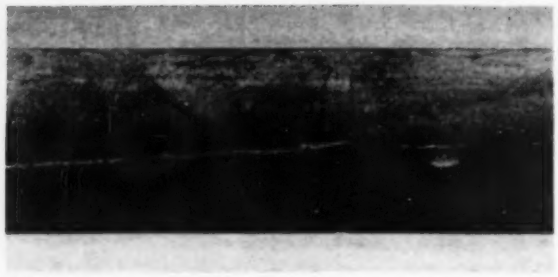

FIG. 5. **Mill seam defect** is caused during manufacture when hot slag from the surface of a steel billet is rolled into the pipe body.

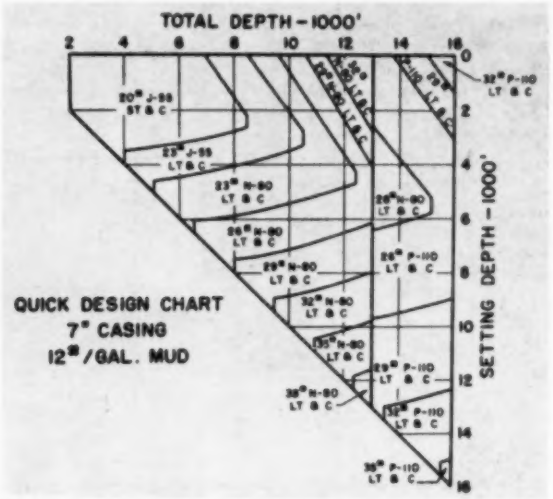

FIG. 7. **Typical casing string design chart** eliminates individual calculations for each casing string. This chart can be used to specify weight, grade, and couplings of a 7-in. string of casing in 12 lb per gal mud.

of rolls where it is formed, pierced and stretched into a piece of pipe — all a continuous operation. But at the end of the line where the pipe must be inspected, a group of men roll it along and look at it for a final inspection. Not only is it a slow process, but some defects get by because a man can't look at a pipe for eight hours without getting eye weary.

The end result is that many oil companies pay a third party to inspect tubular products to have assurance that their pipe for high-pressure service is reasonably free of defects. The independent inspecting company must still depend upon the visual acuteness of their operators even though they use improved equipment — so we still might have defective materials in the well.

Magnetic-particle inspection equipment is being used in mills to some extent and is used by all inspecting service companies. This equipment is manual and depends upon visual inspection. We need engineering developments which will make it possible to eliminate the human element from pipe inspection. The configuration of a defect is often as important as the depth to which it penetrates. A defect which is sharp cornered or irregular is more critical than the slug defect which may penetrate to a greater depth. The stress concentrations which occur at the bottom and ends of sharp edged defects can extend the defect to a point of failure when tension or pressure forces are applied.

Fig. 4 is a photograph showing some cracks on tubing upsets. They were created during the upsetting process. Actually the cracks were not visable until the pipe had been placed in a magnetic field and sprinkled with powdered iron. What you see in the photograph is the powdered iron clinging to the cracks.

Fig. 5 shows a defect known as a mill seam. It is caused by hot slag from the surface of a billet being rolled into the pipe body. The inclusion interrupts the grain structure of the steel causing what appears to be a seam in seamless pipe. This type defect is normally not visable either until the pipe has been magnafluxed.

Fig. 6 shows a rather ominous looking defect in the outside surface of a piece of pipe. This type defect is known as a mill slug. It is caused by a piece of cold steel or slag which has been rolled into the surface of the hot pipe. It can be detected quite readily if the slug has fallen out. This type defect, contrary to its appearance, is often less harmful than the other two. This is not to infer, however, that it isn't detrimental to the casing or tubing.

Handling Procedures

Even the most flawless material or equipment can be made next to useless by improper handling. It is throwing money away if we spend several dollars per joint for inspection to see that we have good pipe, and then allow the pipe to be damaged by improper handling procedures. This is particularly true of tubing.

The improper use of tongs and slips is undoubtedly responsible for more critical damage to casing and tubing than all other things put together. Fig. 13 and 14 are examples of damage to casing and tubing by improper use of tongs. The use of power tongs has been a partial answer to the problem in that the torque is more uniformly applied and the pipe is gripped only once.

A few years ago nearly all casing was made up by pulling the end of the

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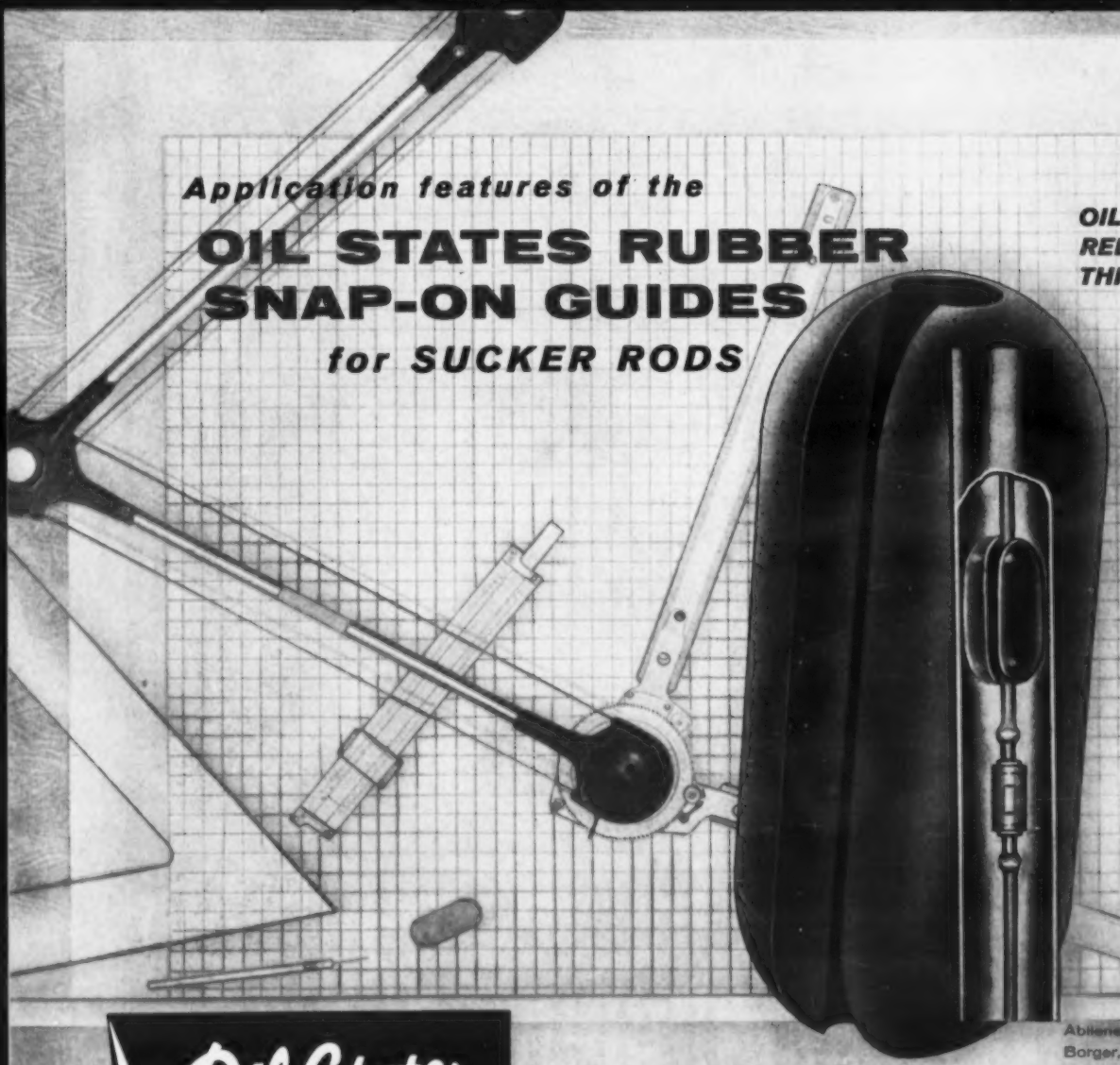

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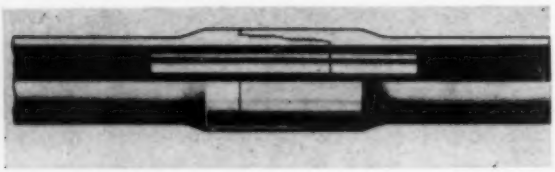


FIG. 8. **Tubing joint** designed to be used on heavy wall tubing seals at both the shoulder and the pin end.

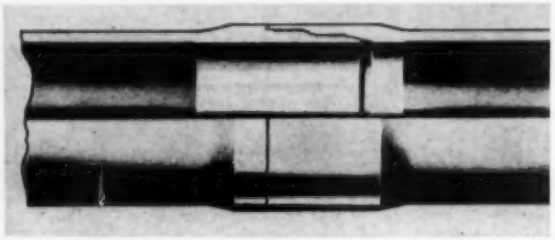


FIG. 10. **External upset casing joint** is used where sealing ability or tension strength of the standard API joint is inadequate.

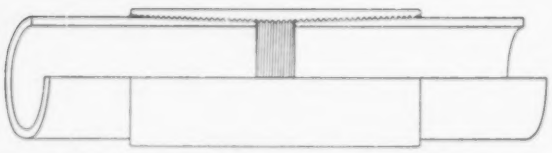


FIG. 12. **Buttress casing joint** has high tension strength. The joint depends upon its thread for sealing as well as for tension strength and is designed for use in the upper portion of casing strings.

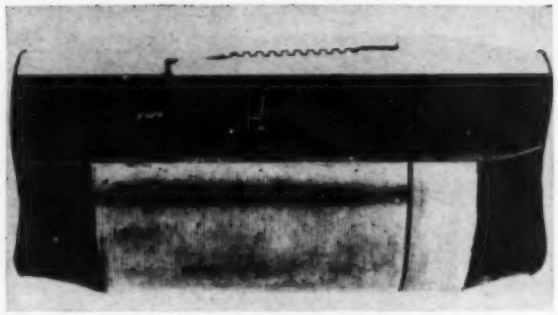


FIG. 9. **Tubing joint** designed primarily for use on standard wall tubing seals at the pin end.

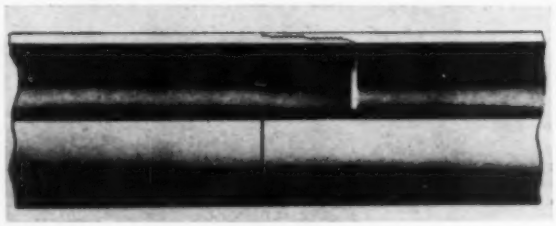


FIG. 11. **Flush casing joint** has threads cut on plain end pipe and does not require an upset. It is used primarily for liners and where clearance is a problem.

pipe tong with a cat line. The load was applied with a jerk and the pipe had to be gripped again after each stroke of the tong. As a result the pipe was often damaged extensively. Power tongs are a big improvement, but not a full answer. We need improved tong dies and improved slips — ones that can't cause deep indentations in the casing and tubing.

Proper make-up of casing and tubing is also very important if we are to have leak resistant joints. Power tongs and improved thread lubricants are very helpful along this line. Considerable effort is being expended by the industry in determining how much torque should be used in making up the various joints. Because of this we can expect considerable improvements to be made within the next year or so in the area of make-up practices.

The selection of the proper size casing and tubing sounds rather elementary, and, it is elementary the way it is being done a lot of places. For years the standards have been 2-in. tubing in 5½-in. casing and 2½-in. tubing inside 7-in. casing. For instance, an engineer suggesting the use of 4½-in. casing is often automatically met with a host of reasons why it can't be done. Yet, actually very few of the objections are really valid when fully analyzed. Such things as "tools aren't available for working inside smaller casing" are often cited. Of course tools aren't always available for some new combinations; however, tools have usually been available by the time the need arises. I don't mean to infer that 4½-in. casing should be used in every well, but it is the engineer's responsibility to examine the requirements and then select the proper size casing.

In the past we have been able to survive even though very little thought has been given to the selection of tubing and casing sizes. This, however, does not justify the approach. And our very survival today depends upon doing an exacting engineering job. So let's look for a moment at how we should go about selecting our casing and tubing sizes. The starting point is the number and size of tubing strings. Once they have been selected the casing sizes are nearly automatic. Each casing string must accommodate succeeding strings.

Tubing size is dependent upon the following factors:

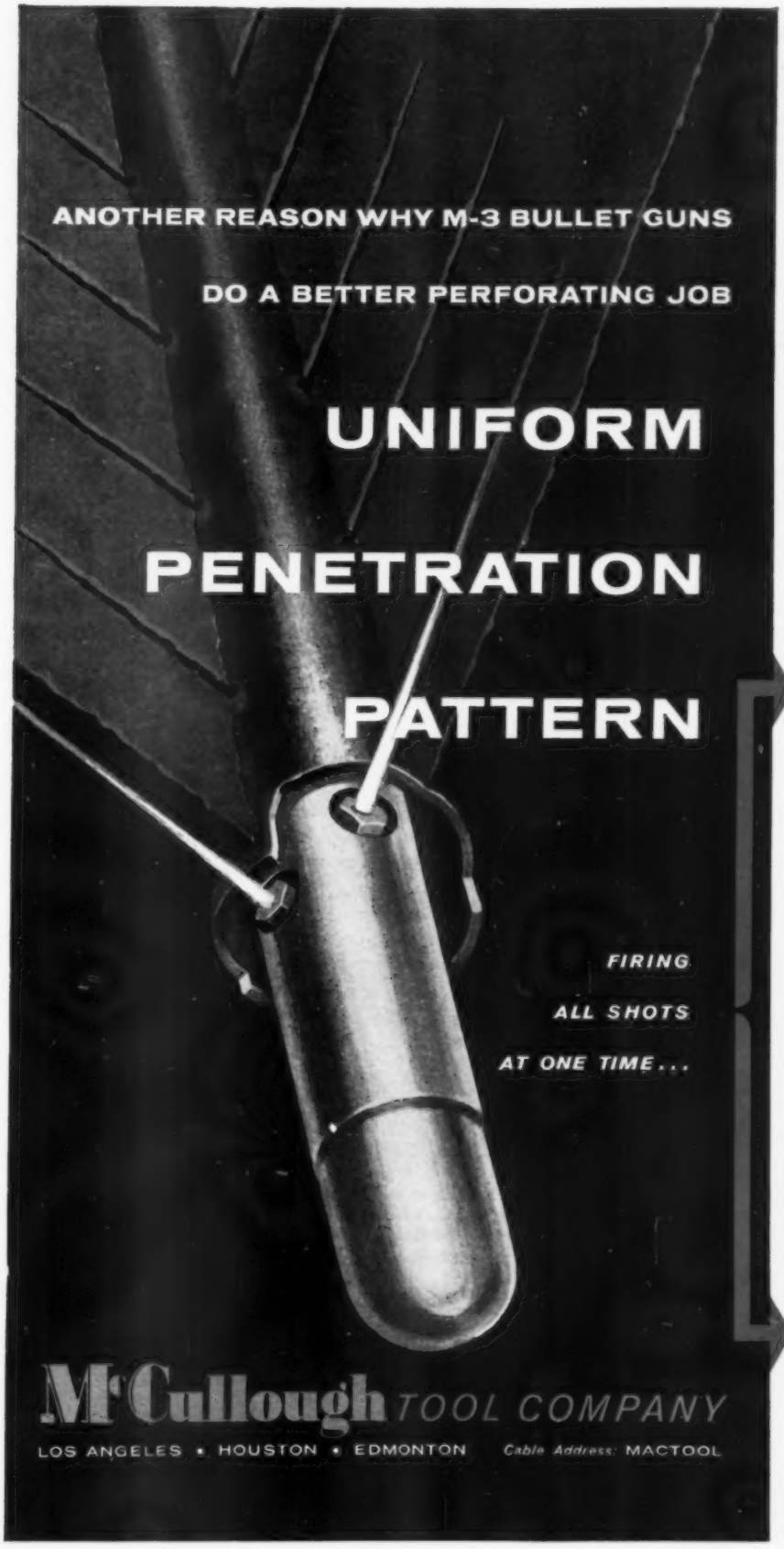
1. Characteristics of well fluids
2. Production characteristics of the well
3. Well depth

The three factors have been listed separately, but they must be considered together. For instance, viscosity and density of the produced fluids must be considered along with desired production rate, well pressure, and depth when sizing tubing. Often the type artificial lift to be used will alter the size tubing and casing required. Stated simply, we should consider all possibilities and then select the smallest tubing and casing sizes which will fulfill the realistic requirements of the well.

The high cost of drilling and completing wells has put a great deal of emphasis on the multiple completion. This is particularly true in offshore drilling where costs are astronomical. For instance, the drilling and completing of a single offshore well may cost $1.5 million. For about $200,000 additional this same well could be made a triple completion if additional producing zones are present. Therefore, we need to recognize these possibilities and plan for them. As an example, Atlantic is a partner with several other operators in offshore drilling. Recently the group made the first quadruple completion ever made using four strings of tubing. As a result, this well will have an allowable of about 1200 bbl instead of only 300.

Special Tubular Products

Earlier I mentioned the orderliness which has been an outgrowth of the API program of standardization. Without detracting from the importance of this program, we shouldn't become so involved with standardized products that we fail to recognize the advantages of some tubular products not covered by API specifications. This refers par-

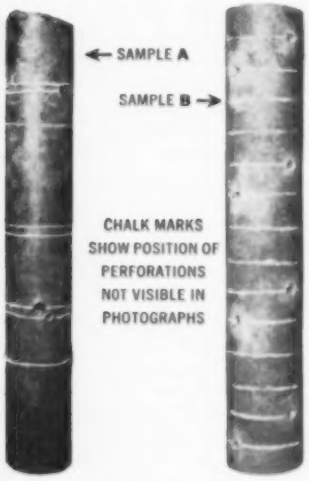


Deep, evenly spaced perforations that *uniformly* cover the productive zone – assure you of the most effective perforating job – and that's what you get when you shoot for production with McCullough M-3 Bullet Guns.

An M-3 Gun fires all shots at one time while the gun is motionless in the casing. Thus, perforations are the exact pattern of the chambers in the gun – in any shot density desired.

Combine McCullough's precise depth measurements with deep, evenly spaced perforations covering the *entire* pay zone and you get maximum drainage from formation to well bore – best possible production.

prevents bunching of shots in one small area in pay zone, giving insufficient coverage – prevents scattering of shots over a wide area, possibly missing the pay zone entirely. Sample A (actual photo of pipe recovered from well) shows the erratic shot pattern produced by a gun firing one shot at a time. As each shot is fired the upward thrust of released gases causes the gun to dance up and down.



eliminates the danger of possible pipe damage or failure. Too many perforations in one spot or in a coupling can cause pipe to part if it is in severe tension. Sample B is an actual example of six shots per foot fired by an M-3 Bullet Gun. Note the uniformity of shot pattern – no danger here of seriously weakening your casing, and you get the most productive perforating job possible.

ticularly to specialized joints for casing and tubing, but the same applies to other specialized properties also. For instance, we have worked out a series of casing designs making use of two specialized products. We have put a high tensile strength joint at the top and a high collapse resistant pipe at the bottom. With this combination the cost of many oil strings will be reduced by about 15 percent.

The so-called premium or special casing and tubing joints are used for one or more reasons. The most important of these are tension strength, leak resistance, and reduced outside diameter. As stated before, money can sometimes be saved by the proper use of special joints. On the other hand, their general use would make the cost of a string prohibitive.

The API casing joint is a relatively inexpensive and rugged joint which is easily made up. For many years the strength and sealing ability of the API casing joint were adequate for nearly all wells being completed. The joint is still adequate for a large number of wells being drilled today; however, the trend toward deeper and higher pressure wells has led to greatly increased usage of the premium casing joints. Also, in some instances where bit clearance or clearance for parallel tubing strings inside casing is a problem, lighter weights of casing together with high strength joints have been used in place of the heavier weights (less ID) of API coupled casing.

Most of the premium joints depend upon auxiliary metal-to-metal surfaces for sealing rather than on the thread alone as does the API joint. For the most part the joints are integral — that is, they don't require a separate coupling. By having only the one thread per joint, the points for possible leakage are reduced. These joints with their auxiliary sealing surfaces and positive shouldering are generally conceded to be superior from a leak resistant standpoint to the API joint.

Fig. 8 through 12 show several of the available specialized tubing and casing joints. Fig. 8 is a tubing joint which is designed to be used on heavy wall tubing. It has excellent sealing and tension properties and is used where well conditions require heavy wall tubing. This joint is designed to seal at both the shoulder and at the pin end.

Fig. 9 is a tubing joint designed to seal at the pin end. The joint is used on standard wall tubing primarily, but it is available in the 2½ in. size for heavy wall tubing. The same thread form is also available on casing.

Fig. 10 is an external upset casing joint. This joint is used where the sealing ability or the tension strength of the API joint is inadequate. Because of its reduced outside diameter and streamlined construction it is often used where reduced clearances are a problem.

Fig. 11 is a flush casing joint. This joint is cut on plain end pipe and does not require an upset. For this reason the joint is only 50 percent efficient from a tension standpoint. The thread is not interchangeable between different weights except in a few instances. Because of its low joint efficiency and because of the lack of interchangeability, flush joint casing is very rarely run as a full string. It is used primarily for liners and to run through existing casing where clearance is a problem.

Fig. 12 is a buttress casing joint. It is a relatively low cost joint which has high tension strength. This joint depends upon its thread for sealing as well as for tension strength. It is designed for use in the upper portion of casing strings where high tension is present.

Conclusion

The time has come when we can no longer afford to approach casing and tubing design in a matter-of-fact way without asking if there is a better way to do it. In accepting this challenge, we must consider three main points. First, we must accept that today's domestic oil industry is not the same as it was a few years ago; our margin of profit has been cut. All of our hoping and wishing will not make it the same! The industry then must change and approach each phase of its operations with the idea of how can we cut costs.

Second, tubular products are not routine items which we just stick in the ground because someone happened to find an oil well. Tubular products in today's wells are so important that the industry's future may well depend upon the engineer's ability to economically match the properties of available products to the requirements of the well.

And third, there are a number of areas needing investigation — investigation at a level requiring a high degree of technical proficiency.

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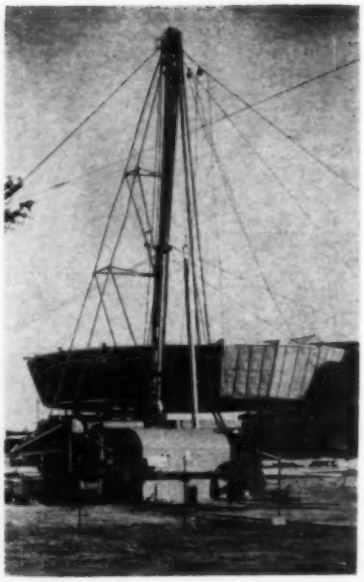

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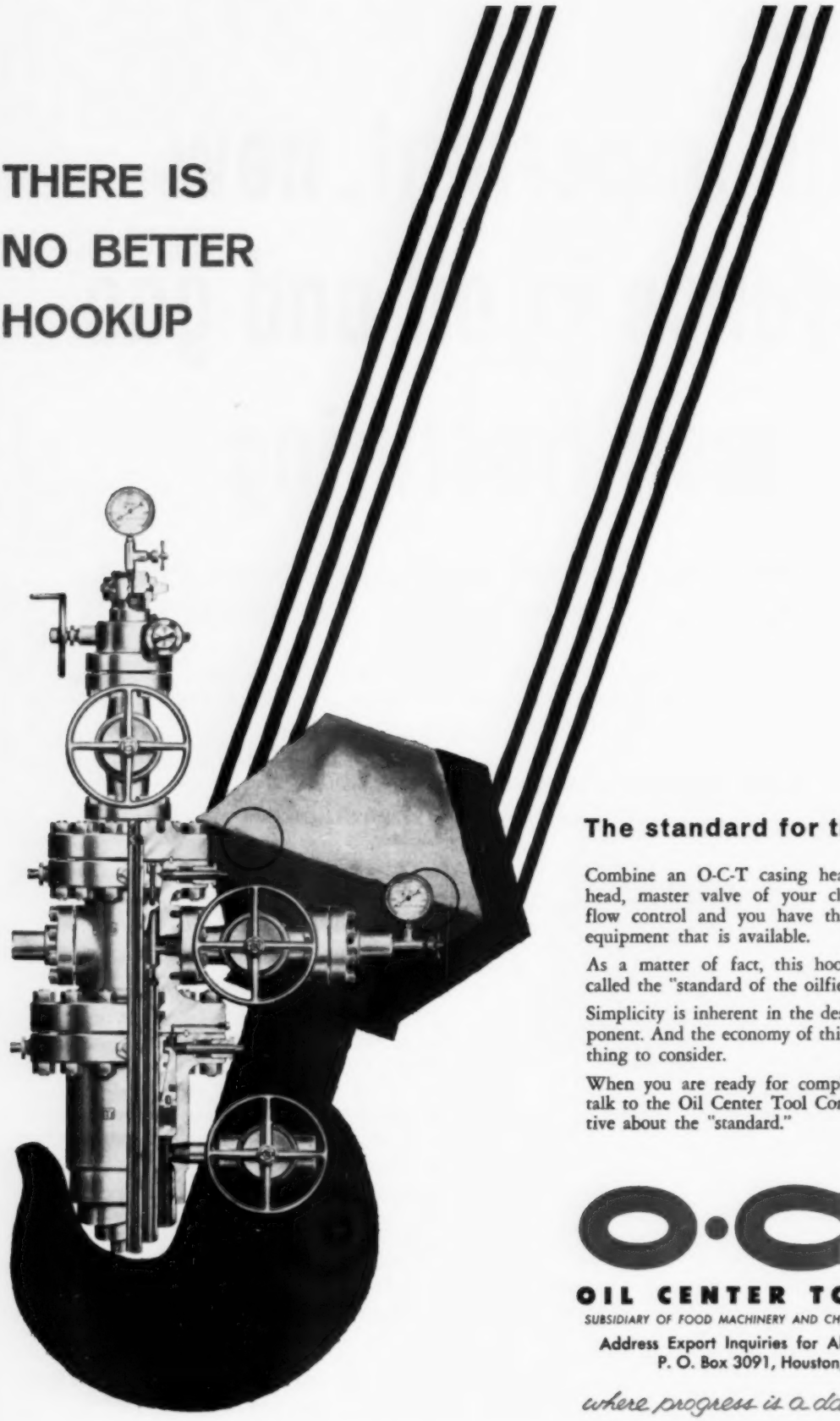

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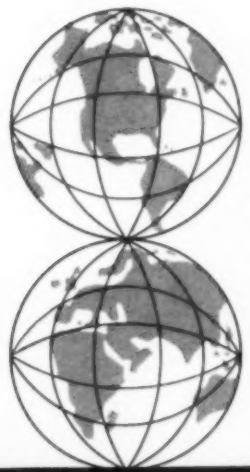

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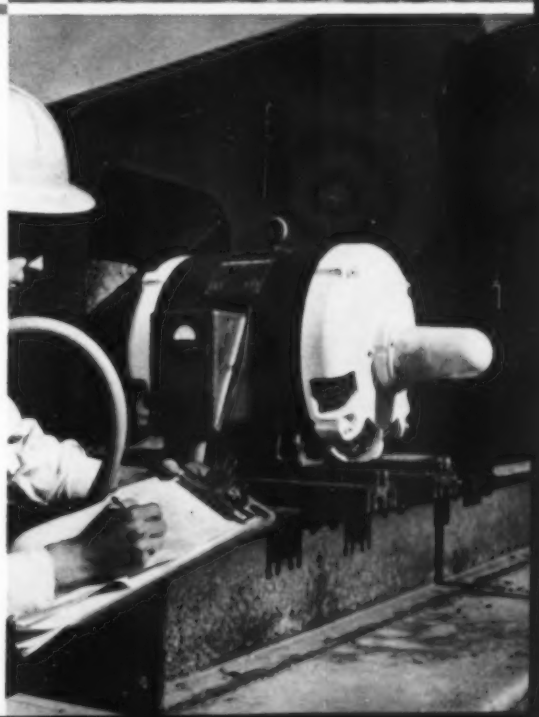

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Part 2

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IN-SITU COMBUSTION is a thermal oil recovery method where the energy required for moving crude oil through the reservoir and eventually into the production well bore is created by injecting air into the reservoir and burning a portion of the crude oil therein. The process is visualized as a slowly moving narrow burning zone which advances from the air injection well to a production well, moving oil ahead of it.

Development History

The idea of recovering petroleum by an in-situ combustion process was first disclosed publicly 35 years ago in patents issued to Edson Wolcott[24] and Frank Howard.[25] The first known attempts to apply an in-situ combustion process in the field in the United States were in 1952 when Magnolia and Sinclair engineers, each group working independently only 300 miles apart in Oklahoma, initiated movements of combustion fronts in pattern-type experiments after several years of preliminary tests.[26,27]

Since that time 7 additional field tests,[28,29,30,31,32,33,34] have been completed; 9 projects, of which 3 have been reported publicly,[35,36,41] are underway at present; and 9 or more projects, of which 5 have been reported publicly,[37,38,39,40,41] are in various stages of planning. A list of the 17 of these projects that have been mentioned in publications and news releases up to the present time is presented in Table 3. Such data as are available relative to location, reservoir properties and type of operation of each of these tests have been included in the table.

It will be noted from Table 3 that the geographical distribution of these tests is country-wide. This is shown

FIG. 8. **Geographic location** of proposed, active, and completed in-situ combustion oil recovery projects in the United States.

Presented before the Interstate Oil Compact Commission at Kansas City, Missouri, December 1, 1958.

Note: This is the second of two parts of the article. The first installment, dealing with oil well heating and hot fluid injection, appeared in the February 1959 issue of THE PETROLEUM ENGINEER.

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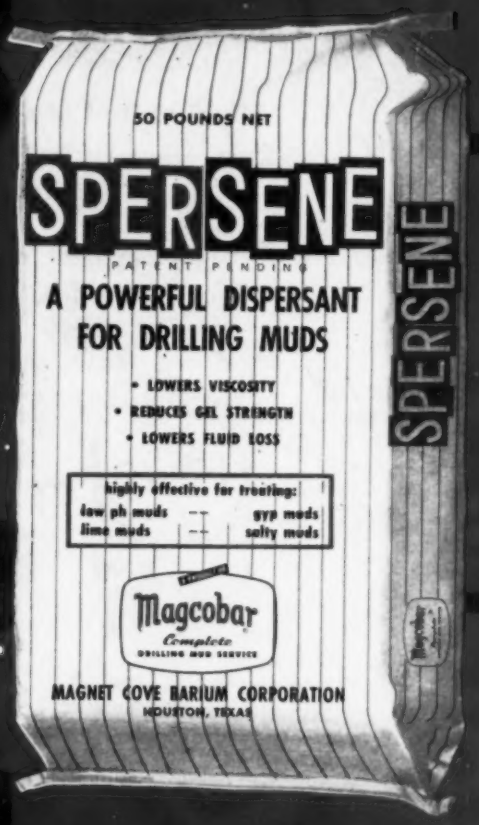

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	1	Thinner A	18.5	14
lime muds	3.0	Spersene	49.5	6
	3.0	Thinner A	65.5	16
low pH muds	1	Spersene	16.5	8
	1	Thinner A	18.5	12
	2	Thinner B	20.0	20
	1	Thinner C	18.0	18
	1	Thinner D	17.0	31
sea water muds	4	Spersene	66	1
	4	Thinner A	74	3

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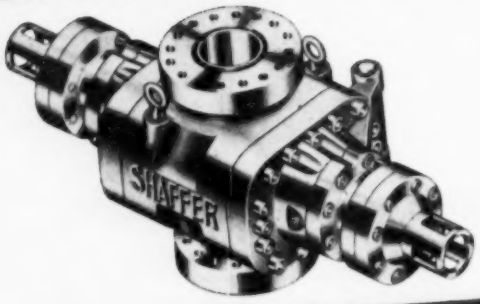

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- Can be operated with portable hand pump that opens or closes rams in 15 to 20 *seconds*. This speeds installation and break-out operations!
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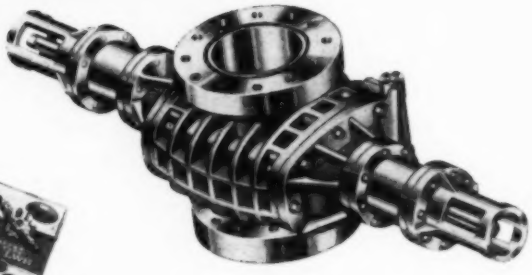

TYPE B and TYPE E GATES for Most Drilling Needs!

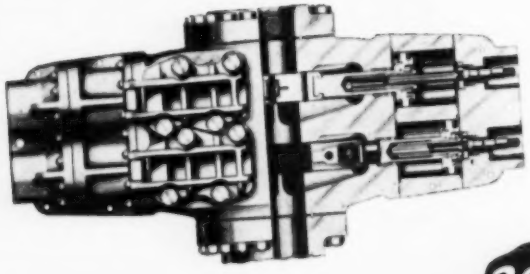

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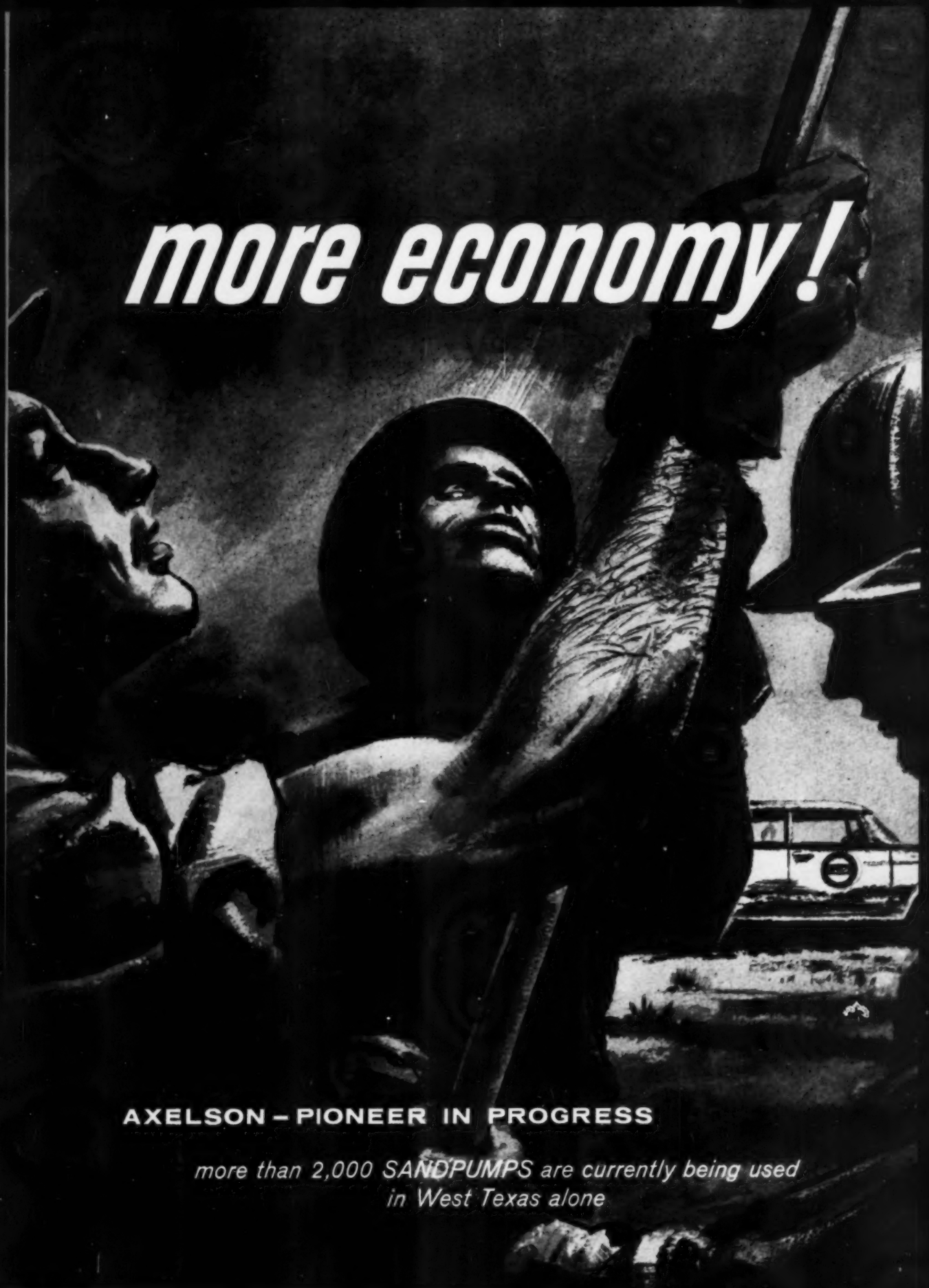
TABLE 3. Some Recent Field Tests of In-Situ Combustion.

		Location			Reservoir Properties						Test Characteristics				
Date[1]	Operator	Field	County	State	Formation	Depth, ft	Thickness ft	Porosity %	Oil Saturation %	Oil Gravity deg API	Well Pattern	Pattern Size Acres	Ignition Method	Injected Gas	Reference
1952	Sinclair	Delaware-Childers	Nowata	Oklahoma	Bartlesville Sandstone	600	26	21	44	36	7-well (inverted)	5.2	downhole gas burner	air, product gas, natural gas	27
1952	Magnolia	West Loco	Jefferson	Oklahoma	Pontotoc Sand	180	20	29	60	18	3-well (in line)	(2)	electrical	air	26
1953	Magnolia	West Loco	Jefferson	Oklahoma	Pontotoc Sand	180	20	29	60	18	5-well (inverted)	0.07	electrical	air	28
1953	Worthington-Forest Oil	Parker	Clark	Illinois	Pennsylvania Sand	275	35	21	42	26	5-well (inverted)	0.28	injection gases heated at surface	steam, air, combustion gas	29
1954	Cal. Research, California Co.	Irvine-Furnace	Estill	Kentucky	Corniferous Limestone	70 to 1200*	0-61*	*	*	30-36*	*	*	*	*	30
1955[3]	Sinclair	Spraberry	*	Texas	—	8000*	10-165*	12-18*	*	32-42*	*	*	*	*	31
1956	Sinclair	Humboldt-Chanute	Allen	Kansas	Bartlesville Sandstone	600	23*	20	*	25	3:1 line drive	(4)	*	*	35
1956	General Petroleum[5]	South Belridge	Kern	California	Tulare Sand	700	30	37	60	13	5-well (inverted)	2.5	spontaneous	air	32
1956	Cal. Research	Midway-Sunset	Kern	California	*	2000	*	*	*	20	4-well (inverted)	1.2	downhole gas burner	air	33
1956	Richfield	Sisar-Silverthread	Ventura	California	Miocene Sandstone	1000*	*	*	*	11-30*	*	*	*	gas and air	34
1957[6]	Southworth and Wood	Camp Hill	Anderson	Texas	Carrizo Sand	420	32	35	*	19	*	*	Injection gases heated at surface	heated air	36
Proposed	Sohio	—	Uinta	Utah	Asphalt Ridge	*	*	*	*	*	*	*	*	*	37
Proposed	Creole	*	*	(Venezuela)	*	*	*	*	*	*	*	*	*	*	38
Proposed	Deford	Coleman Co. Regular	Coleman	Texas	Amerada Sand	200	18	24.4	*	*	5-well	5	injection gases heated at surface	air	39
Proposed	Conka Prod. Co.	Brown Co. Regular	Brown	Texas	Strawn Sand	1250	12	*	*	*	*	*	*	air	40
1958	Shell	Tia Juana	*	Venezuela	*	*	*	*	*	*	*	*	*	*	41
Proposed	Shell	Cabimas	*	Venezuela	*	*	*	*	*	*	*	*	*	air and recycle gases	41

*Specific data not released; values given are from published field data.
[1]Date of initiation of specific test, where available; otherwise, date of publication.
[2]40 ft between injection well and most distant production well.
[3]Failed to initiate a moving combustion front.
[4]Two or more rows of input wells about 150 ft apart, spaced 400-450 ft from rows of production wells.
[5]Participating companies: Continental, Esso Research and Engineering, Gulf, Honolulu, Ohio, Shell Development, Sunray-Mid Continent, Texas, Tidewater, Union, Chanslor-Western.
[6]Whether ignition of oil sand is planned in this test has not been announced.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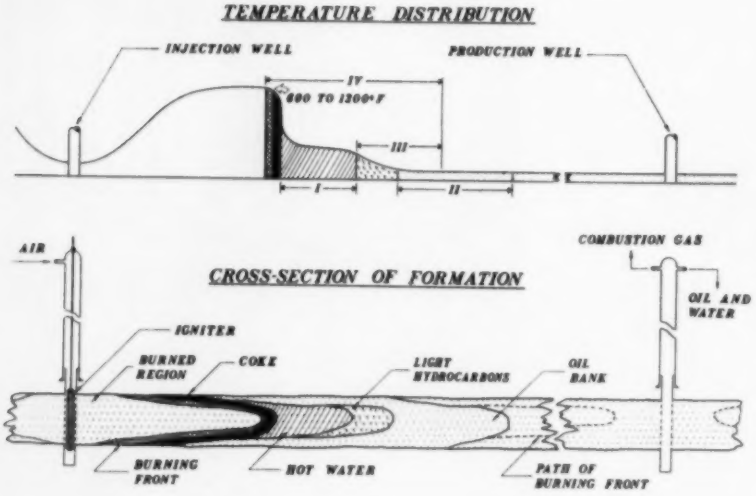

FIG. 9. **Mechanisms** of the in-situ combustion process.

even more clearly in Fig. 8 which is a map of the United States on which the location of proposed, active and completed in-situ oil recovery projects are shown as black dots.

Basic Concepts

As explained previously, the in-situ combustion process consists basically of igniting the oil in a reservoir, and moving this burning front slowly from one well to another by continuous injection of air. Examples of this basic process that have received some attention are:

1. **The "heat" wave process** which involves the formation of a large heat wave to be propelled by gases of limited oxygen content to control the rate of advance of the burning front,

2. **Halting combustion part way** between the injection well and the production well and propelling the heat wave toward the production well by cycling the produced gases and,

3. **Use of a "reverse combustion" technique** where the combustion is halted part way between the injection well and the production well and air flow is reversed by injecting air into the production well and turning the original air injection well into a production well.

While these variations may result in improvements over the basic in-situ process in certain reservoirs, they all involve the same general principles, and for that reason, the present discussion will be limited to the basic in-situ combustion process itself.

As the burning front moves slowly from the air injection well to the production well in the basic in-situ process, a number of different but intimately related oil displacement mechanisms are believed to occur simultaneously. These mechanisms are illustrated in Fig. 9, and are described below.

1. **Condensing steam drive:** When the heavy residual oil retained on the sand is burned at the high-temperature burning front, steam is one of the products. This steam along with that produced by vaporizing the interstitial water in the burned sand, loses heat rapidly upon contacting the cooler sand ahead of the burning front, resulting in a condensing steam type drive. The large amount of latent heat produced by condensation of this steam imparts substantial energy to the oil to decrease its viscosity and enhance displacement.

2. **Gas drive:** The gaseous combustion products (nitrogen, carbon dioxide, and carbon monoxide) transfer heat to the oil, and further increase its mobility by partially dissolving in it. The oil bank which forms due to increased mobility and volume is displaced physically by the remaining combustion gases.

3. **Miscible drive:** Burning front temperatures are known to cause mild cracking of the oil to produce light hydrocarbons. Blending of these hydrocarbons with the heated oil increases its mobility, and improves oil displacement by creating a hydrocarbon transition zone.

4. **Thermal drive:** Burning of the heavy residual oil is responsible for all of the drive mechanisms described above. In addition, thermal energy is transferred to the oil by conduction through the sand and through the reservoir fluids.

Further basic concepts related to the operation of an in-situ combustion process concern the nature of the producing unit (area and well pattern) and the sweep efficiency involved. With regard to the former, the size of an individual producing unit is dependent on the number and producing capacity of the wells and the air injection characteristics of the reservoir. Experience to date indicates reasonable assurance that 5-acre patterns are practical to operate, with good possibilities of going to larger sizes. Well patterns involving a central air injection well with four or more producing wells spaced uniformly around the perimeter seem best suited to the process at present although further development work may show other patterns to be more suitable.

In two field tests conducted to date, the volumetric sweep efficiency — i.e., the percentage of total pattern volume that was burned—was reported to be 26 percent in one case[28] and 39 percent in the other.[32] Volumetric sweep efficiency is a key factor in determining the amount of air required in the process.

A knowledge of volumetric sweep efficiency is also quite helpful in visualizing the mechanism of oil recovery involved in the in-situ combustion process. For unlike waterflooding and other recovery processes, not only is oil recovered from the swept volume (i.e., the burned out volume in the in-situ combustion process), but appreciable quantities of oil in the unburned portions of the reservoir are produced by the hot gas drive resulting from the conduction of heat to these regions. This is clearly shown by oil recoveries of 50 percent and higher obtained in field tests reported to date.[28, 29, 32]

This discussion is intended to emphasize the fact that the in-situ combustion recovery process is a new type of oil recovery operation, and that the use of previous oil production concepts in analyzing its application must be tempered accordingly. This philosophy will need to be extended as well to oil producing regulations in those states where pro-rationing is used. In other words, the in-situ combustion process is sufficiently different from other more conventional oil recovery methods, that state regulatory bodies should con-

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More on the next page . . .

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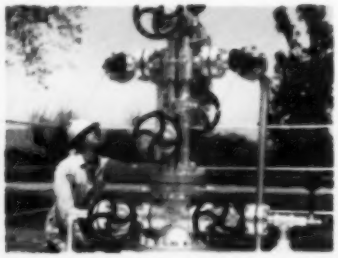

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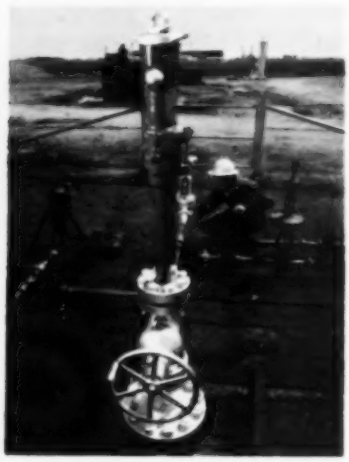

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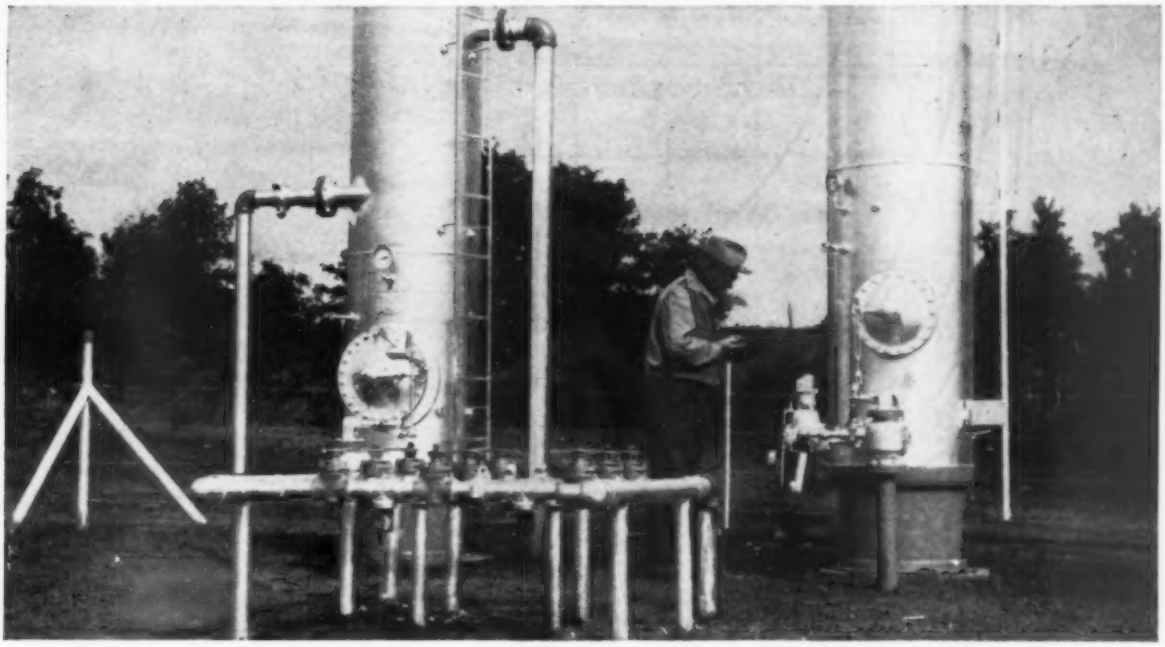

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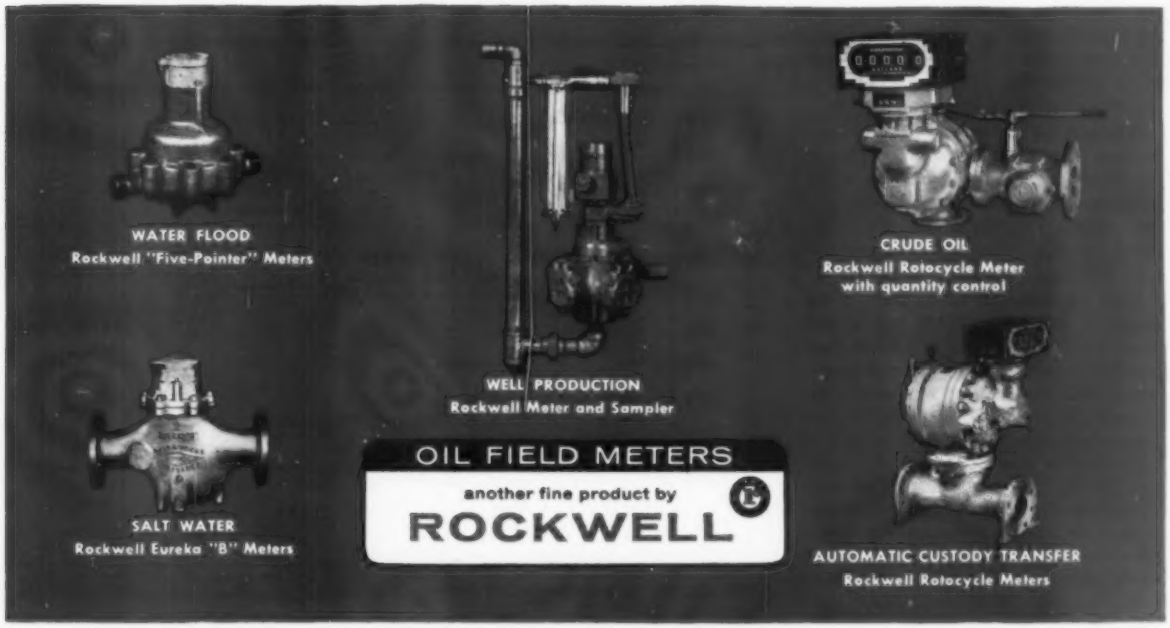

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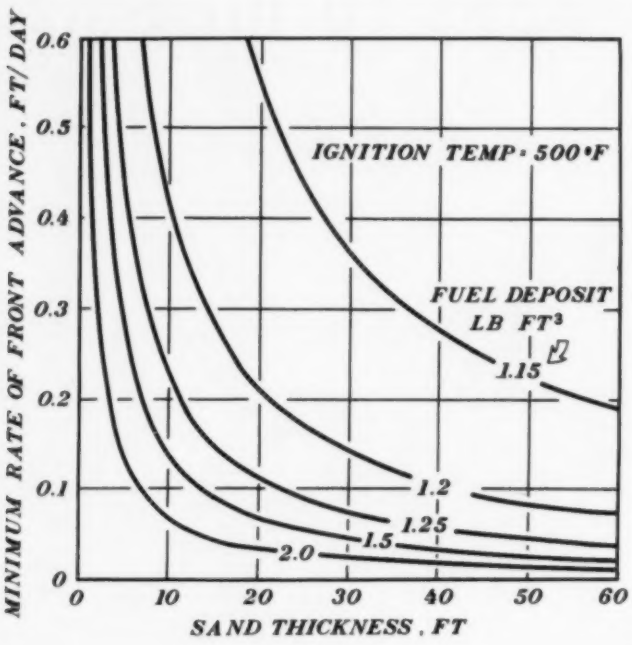

FIG. 10. **Minimum burning rate** in an ideal line drive system.

sider it as a special problem and see that present regulations are either interpreted or adjusted in a manner that will provide equitable treatment and appropriate incentives for in-situ recovery projects.

Design Factors

The principal items to be considered in designing an in-situ combustion operation are the amount of air required, the rate of air injection, the air injection pressure, and the amount and rate of oil production. These items are discussed individually below:

Amount of air required. The total amount of air required to burn a given reservoir unit area and pattern is dependent on the unit fuel consumption, the oxygen utilization and the volumetric sweep efficiency (volume of sand burned).

Unit fuel consumption figures in the range of 240 to 280 bbl per acre-ft have been reported from recent field and laboratory tests.[28,32] The composition of the fuel burned was somewhat variable, as indicated by atomic hydrogen-carbon ratio ranging from 1.67 to 2.73. Taking averages of 2.2 H/C ratio and 260 bbl per acre-ft for fuel consumption, the amount of air required to burn an acre-foot of sand at 100 percent combustion efficiency calculates to be 16.8 MMcf. Oxygen utilization has been reported[28,29,32] to be upward of 90 percent and volumetric sweep efficiency has been discussed earlier as being possibly around 35 percent.

By combining the above figures, the actual air requirement is calculated to be approximately 17.8 MMcf per acre-ft of burned sand or 6.2 MMcf per acre-ft of total sand in the pattern. Doubling this to provide a 100 percent margin of safety in design would bring the air requirement figure for design purposes to 12.4 MMcf per acre-ft. A partial check on this figure can be made by referring to the actual ratios of injected air to produced oil that have been obtained in field tests.

The most reliable figures to date in this regard are believed to be those from the South Belridge test[32] which were 19 Mcf per bbl cumulative with 15 Mcf per bbl or slightly less being achieved during a large portion of the combustion phase of the test. At the reported oil recovery of 880 bbl per acre-ft, the air requirement in the Belridge test calculates to be in the range of 13.2 MMcf per acre-ft to 16.7 MMcf per acre-ft.

Since there is reason to believe that these figures can be reduced in subsequent operations, particularly in developed patterns, it would appear to be reasonable for the present at least to use the above suggested figures of 12.4 MMcf per acre-ft for design purposes. It may be noted that even this figure, at a somewhat lower oil recovery (say, 750 bbl per acre-ft), would be equivalent to about 16.5 Mcf per bbl.

Rate of air injection. The rate of air-injection is determined by the rate of burning front advance which is selected. This is in turn limited—on the lower end by the minimum rate of front advance needed to maintain combustion, and on the upper end by the ability of the producing wells to produce the oil, as well as by the economics of the air compressor installation and operation.

One field test[28] has indicated that the minimum rate of front advance could go as low as 0.12 ft per day. However, this figure can be influenced considerably by the characteristics of the reservoir, particularly fuel deposit

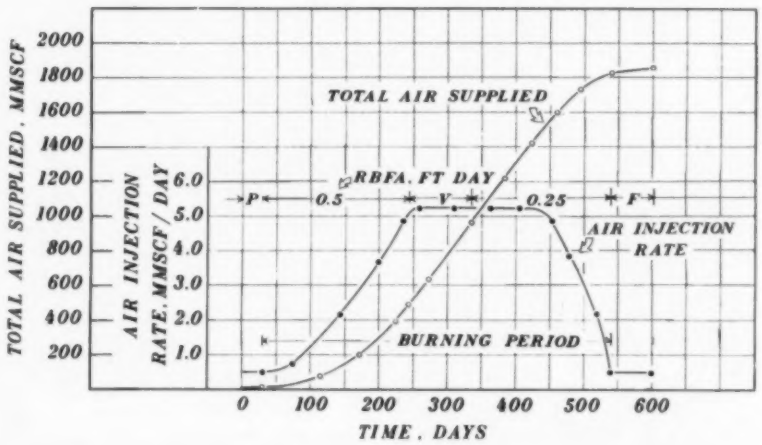

FIG. 11. **Air requirements** for inverted developed 5-acre 5-spot well pattern with 30-ft formation thickness.

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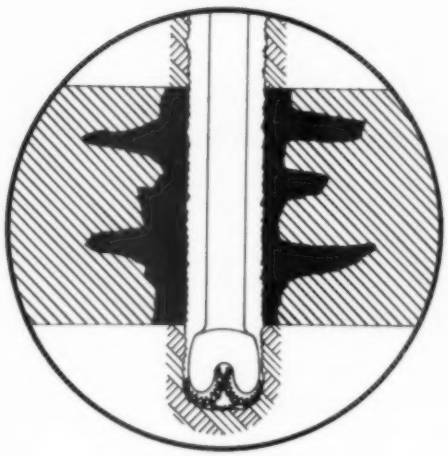

HYDRO-LOK (HG-10), the resin used in PC-11, contains no inert solids; therefore, its primary application is for conditions where maximum resin penetration is required.

HYDRO-LOK (PWG) is a low viscosity fluid that sets to form a stiff gel. The low viscosity is maintained for 95% of its pumping time, aiding entry into the true permeability of the water bearing formation. When PWG enters its setting phase, an extremely stiff gel results in less than an hour, thus minimizing costly rig downtime. Other advantages of HYDRO-LOK (PWG) include:

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- **Is insoluble in water, acid or oil.**
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The Halliburton HYDRO-LOK group of materials has demonstrated water control effectiveness in many field applications. For better water control in air or gas drilled wells *and* grouting operations, specify Halliburton HYDRO-LOK.

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and formation thickness, as shown in Fig. 10.* For design purposes at the present time it is suggested that a minimum figure of 0.25 ft per day be used. Maximum rates of front advance as high as 3.0 ft per day have been reported[32] but these rates were maintained for only short periods.

From a practical design and operating standpoint, it would seem logical to start burning at some higher rate than the minimum and then gradually reduce the rate so as to maintain permissible oil production rates in the individual wells. The latter is a particularly important point to watch in developed patterns where a single production well may be accepting oil from several burning patterns at the same time and where oil may be lost to adjacent depleted patterns.

After a rate schedule for the burning front advance has been selected, the actual air injection rates can be calculated from a knowledge of the air required to burn a cubic foot of the formation and the air flow distribution factors associated with the sweep pattern of the burning front. An example of the results of such a calculation for a hypothetical case of an inverted developed 5-acre 5-spot well pattern with a 30-ft formation thickness is given in Fig. 11.

It will be noted in this case that the range of burning front advance has been arbitrarily set at 0.25 to 0.5 ft per day, and that a short preliminary air injection period (designated by the letter P) and a short final air drive period (designated by the letter F) have been added to arrive at an overall burning time for the pattern of 600 days. The letter V in Fig. 11 denotes a period of the operation during which the rate of burning front advance is gradually reduced from 0.5 ft per day to 0.25 ft per day.

Further examination of Fig. 11 shows clearly that if only one individual pattern is operated at any one time, there would be idle compressor capacity during the early stages and during the final stages of the operation when the air injection rates are far less than the full capacity of the compressor.

One way of avoiding this would be to schedule several patterns to be burning simultaneously, but at different stages of their burning cycle, so that the total air required from the compressor plant at all times is relatively constant. For the example indicated, this can be accomplished by scheduling a new pattern to start every 150 days,

*The minimum rates of burning front advance shown in this figure were computed for a heat front moving linearly through a porous system having a thermal diffusivity of 0.04 ft per hr. The heat of combustion of the fuel was assumed to be 16,000 Btu per lb; and the minimum rate of burning front advance was taken as that required to maintain the upper and lower edges of the front at the selected ignition temperature.

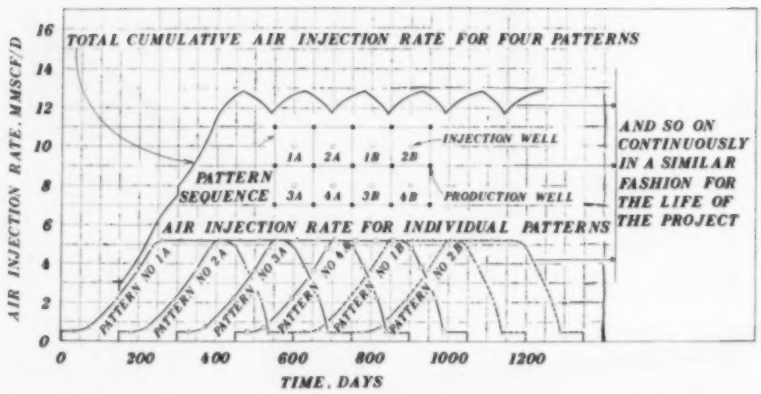


FIG. 12. **Air injection rate** for operating combination of four inverted, developed, 5-acre 5-spot well patterns spaced apart by 150 days.

which results in operation of four patterns simultaneously with a total operating cycle of 600 days for each individual pattern. The net result of such an arrangement in terms of air rate requirements is shown in Fig. 12.

This example should not be construed as an optimum or recommended operating plan. It is only one possible arrangement of which there are many.

Air-injection pressure. Permeability of the formation to air, selected air rate, well spacing and formation depth determine the air-injection pressure. There are ways of estimating the required pressure by calculation but these are not particularly satisfactory. The preferred way is to run actual air-injection tests in the field. For design purposes, the values obtained in such tests should be increased by some reasonable factor of safety to take care of pressure increases that may come about temporarily during the combustion operation. Examples of air-injection pressures that have been required in field tests to date are 90 psig for a reservoir 200 ft deep in Oklahoma[28] and 200 to 300 psig for a reservoir 700 ft deep in California.[32]

Amount and rate of oil recovery. Reported recoveries of oil by the use of in-situ combustion range from 51 percent[28,32] to as high as 80 percent[29] of the oil originally in place at the start of the process. In all cases, this recovery has been obtained in 1½ to 2 years' time. These results illustrate two of the important features of the in-situ combustion process. (1) Its ability to recover high percentages of the oil in place and (2) its ability to do this in a relatively short time.

Available data on the rate of oil recovery indicates that production rate starts to increase shortly after combustion starts, and reaches levels during the middle and latter stages of operation that are 12 to 15 times higher than the original production rate before combustion. In field tests to date, individual well rates, and even pattern production rates tend to be erratic because of uneven advances of the combustion front, and because sanding, corrosion, high temperature and other problems have affected individual producing well performance. Indications are that the produced oil has a higher gravity (1 to 2 deg API), and a much lower viscosity (3 to 10 fold) than the original oil in the reservoir.

From an engineering design standpoint, it appears that oil production facilities could be based on using conventional lease equipment, with the following exceptions:

1. Heavy duty treating equipment. Rather severe emulsions are possible, particularly at certain stages of the operation, and heavy duty heater treaters, as well as extra emulsion breaking chemical material may be required to treat the oil to pipeline specifications.

2. Special liners, well cooling and corrosion control equipment. Serious failure of downhole piping, particularly liners, is possible because of high temperatures and corrosive conditions that can exist if the burning front passes through or gets too close to a production well. Stainless steel liners with well cooling (either by coils or by direct injection of water at the bottom of the hole) have given the best performance to date as far as the bottom of the hole is concerned, but even better equipment would be desirable. Injection of chemical inhibitors shows definite promise of handling uphole corrosion problems satisfactorily.

One thing to be kept constantly in mind is that the life of the well equipment in an in-situ combustion operation needs to be only a small fraction of that usually required by conventional producing methods. This not only broadens design considerations appreciably, but suggests that radically different completion methods may come into use with the in-situ com-

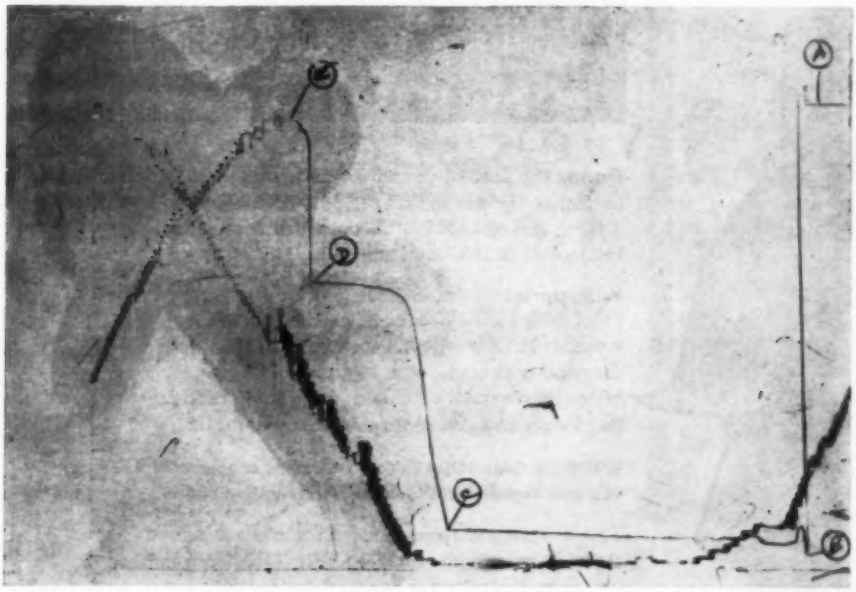
168 Barrels Of Oil A Day From A Dry Hole

This is the story of how an apparent dry hole was made a 168 bopd producer. The well was drilled by Mr. A. C. Torgeson of Torgeson Oils, Inc. who realized a successful producer from a wildcat well that could easily have been abandoned. The well was spudded in Weld County, Colorado, and was projected for the "J" sand around 6900 ft. The sand, when reached, was cored and an electric log was run. These revealed conclusively that the "J" sand was unproductive . . . that it contained only water. Had it not been for the alertness of the consulting geologist on the well, Paul "Skipper" Keller, the well would have been plugged and abandoned. Keller, however, had noticed an oil show in the cuttings from the "D" sand approximately 100 feet up the hole. The "D" sand was generally unproductive in the area and a thorough study of all available evidence indicated that it probably would be unproductive in this well even though there was a show in the cuttings. Normally a well of this type would have been abandoned immediately, but Mr. Keller was reluctant to do this in spite of the seemingly overwhelming odds against making a successful producer. The decision was then made to run a drill stem test in order to evaluate all the available information. The result was a producer!!!

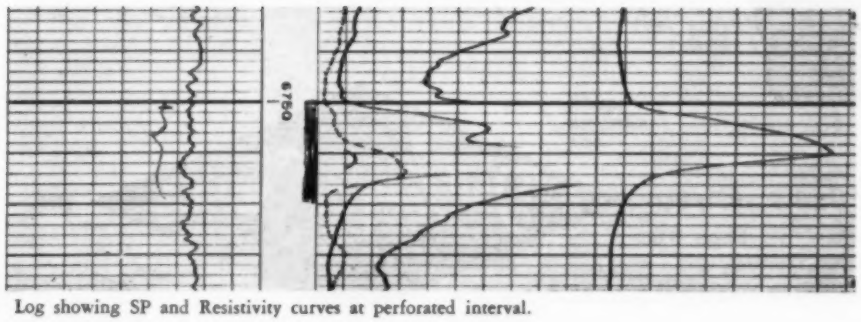
To obtain the test information which resulted in a positive decision to complete the well, Johnston Testers was called in from the Fort Morgan office and a straddle test was run. On the basis of the drill stem test, casing was set and the well perforated from 6758 to 6764 ft. The initial flow of the well was 168 bopd through a 30/64" choke. No well stimulation treatment was required and a dry hole became a producer.

This is an excellent example of the necessity of gathering and evaluating all the data possible before setting casing on a well that might be dry, or before abandoning a possible producer.

This well clearly demonstrates that it is unwise to discount any possible pay or write-off any well prematurely. It also demonstrates that Drill Stem Testing pays off in handsome dividends. The cost of a drill stem test is very small compared to the investment made in the drilling of the well. Test—to be absolutely sure.



Drill Stem Test chart for the Torgeson State No. 1. Tool was open for two hours with forty-five min. shut-in. Gas to surface in 18 min. (800,000 cu. ft.) and a good blow was observed. 550 ft. of oil and 270 ft. of oil and gas cut mud were recovered. No water was present. Initial flow (B) was 108 psi and final flow (C) was 291 psi. Final shut-in pressure (D) was 2221 psi.



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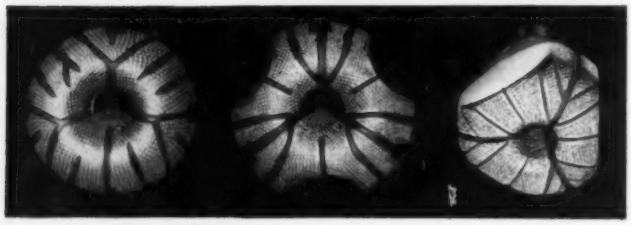

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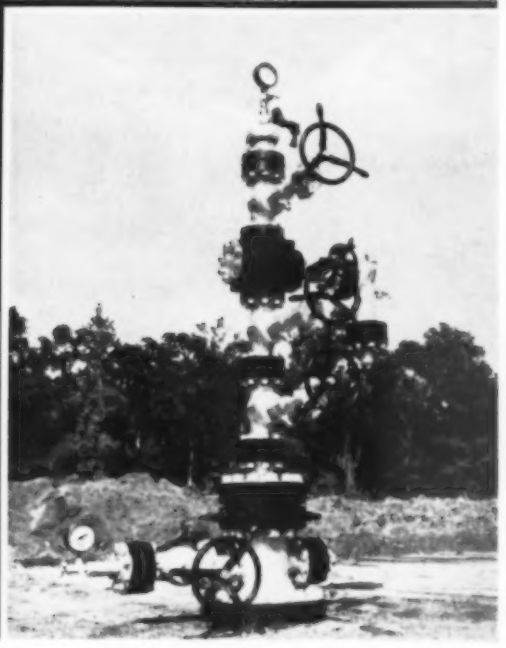

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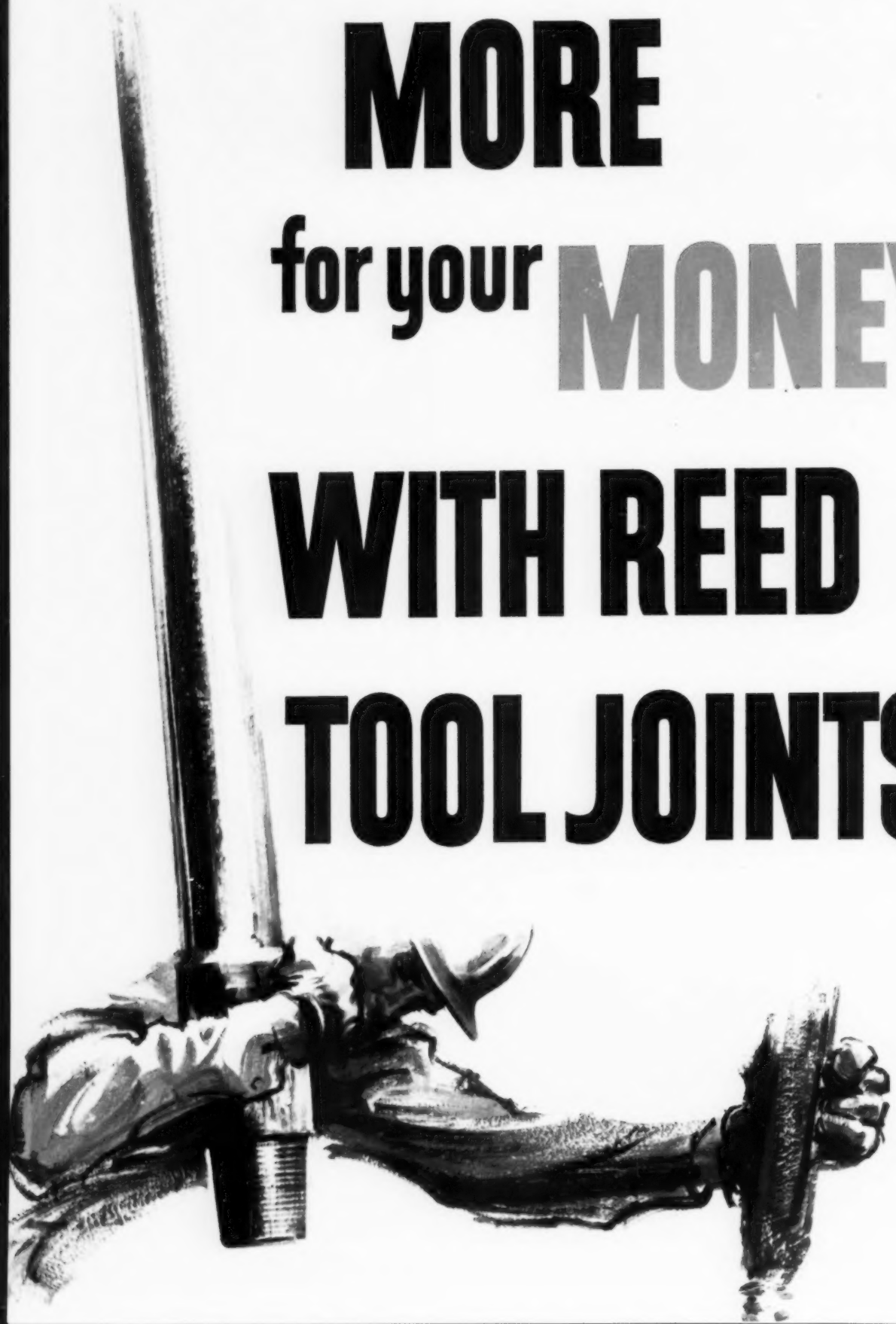

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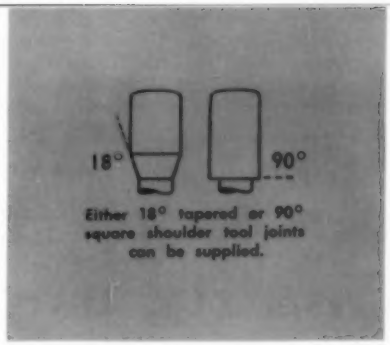

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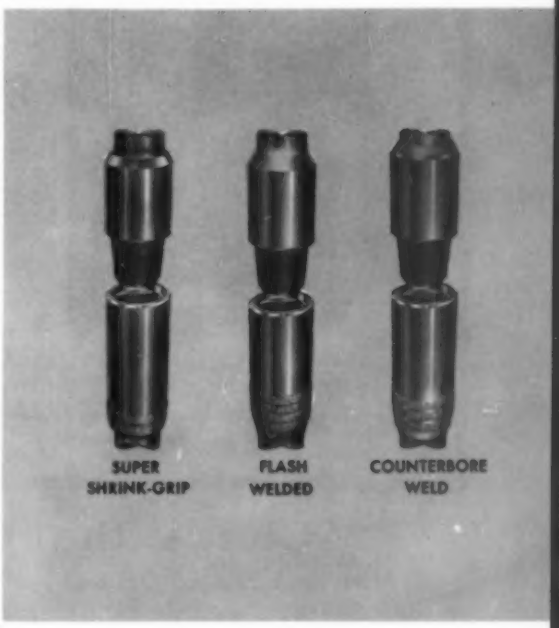

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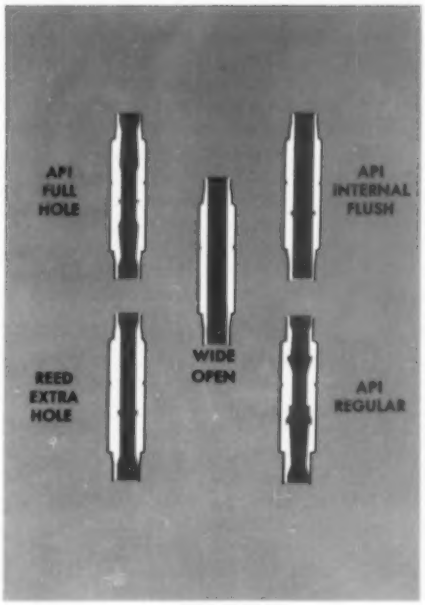

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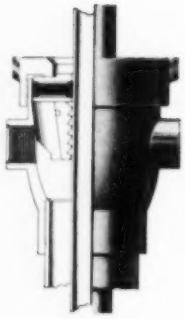

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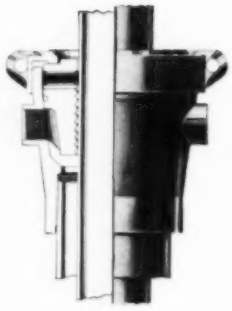

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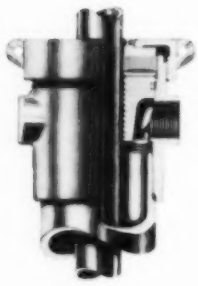

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bustion process as it becomes further developed.

3. Produced gas processing equipment. The produced gases are principally combustion gases (N_2, CO_2, CO and H_2O) but they also contain small amounts of light hydrocarbons and oxidized materials that may be worth recovering for economic reasons. In addition, if there should be any sulfur compounds in the gas, it may be necessary to treat the gas for air pollution reasons, particularly in populated areas. Methods and equipment are available for handling either of these problems, economically and without difficulty.

Economics

The primary factors to be considered with regard to the economics of an in-situ combustion process are original oil content of the reservoir, percentage oil recovery, crude oil price, air compression costs, well drilling and maintenance costs, and lease operating costs. Laboratory and field development work to date has provided data with regard to these factors that can be used as a guide in preparing economic estimates of a commercial in-situ combustion operation. In the present discussion, this will be illustrated by presenting a typical case evaluation of a hypothetical commercial operation of an in-situ combustion project.

The actual costs experienced in field pilot tests of in-situ combustion conducted to date have been quite high because of the experimental nature of such projects. In a full-scale commercial operation, where equipment installation and operating procedures have been optimized on a regular production basis, it is reasonable to expect that these costs might be appreciably lower. However, this possibility has been taken into consideration only to a limited extent in the present economic calculations in order that the results could be presented on a conservative basis.

The basic field conditions assumed in the present example are:

Areal extent of reservoir	240 acres
Depth of reservoir	1000 ft
Thickness of saturated oil sand	30 ft
Original oil in place	1500 bbl per acre-ft

The unit operating pattern was assumed to be a 5-acre 5-spot which refers specifically to a square of 5 acres with an injection well in the center and a producing well at each of the 4 corners. The operation was scheduled so that 4 of these 5-acre patterns would always be operating simultaneously, but separated in their burning cycle by 150 days, and each having a total burning time of 600 days. This is the same operating cycle that was discussed previously under the section on air injection rate, and illustrated graphically in Fig. 12.

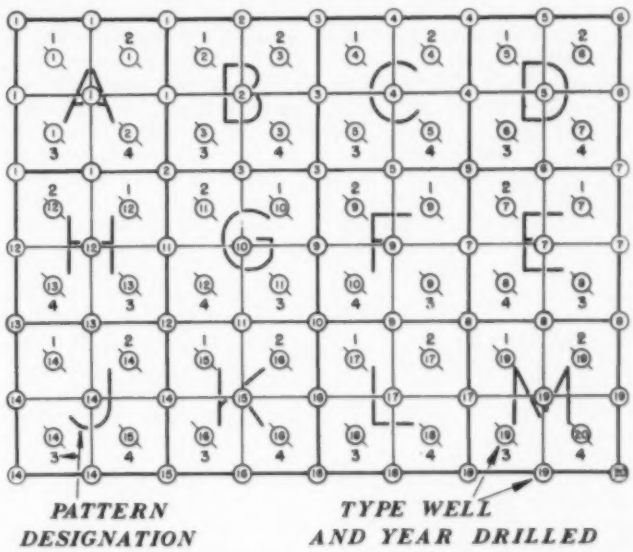

FIG. 13. **Well layout diagram** for developing 240-acre field with 5-acre 5-spot pattern.

The manner of applying this type of operation to the hypothetical field in the example is shown in Fig. 13. It is assumed that the operation would commence with ignition of pattern No. 1A, followed at 150-day intervals with ignition and burning of patterns 2A, 3A, 4A, 1B, 2B, 3B, 4B, 1C, 2C, etc., until the entire 240 acres had been burned. The compressor plant and tank battery would be located near the center of the 240-acre property and air injection piping and oil collection lines would be shifted from time to time across the property as the operation progressed.

Wells are drilled only as needed during the life of the project, and the numbers alongside the wells in Fig. 13 indicate the year of the project that this drilling should be done. The total life of the project is 21 years, and it has been assumed that the working life of of the compressor equipment could be matched to this. Average daily production from the property, assuming recovery of 50 percent of the oil in place, will be about 750 bbl.

Air requirements were assumed to be the same as those indicated in Fig. 12, discussed previously, and the air injection pressure was assumed to be 300 psig. Compressor hp requirements were calculated to be about 3000 bhp. Using a unit cost of $225 per bhp, the cost of the compressor installation was calculated to be $675,000. Adding the costs for ignition equipment and air delivery piping, the total investment cost for this part of the operation came to about $720,000. Operating costs for the compressor plant, including labor, fuel, lubrication, maintenance, and all fixed charges, exclusive of amortization, were calculated to be about $180,000 per year, equivalent to about 4 cents per Mcf of air.

Costs for drilling and casing 1000-ft wells were set at $10 per ft, and as a special factor of safety, it was assumed that 50 percent of the producing wells would be drilled twice in light of the well failures that have been experienced in some of the field tests conducted to date. It seems quite likely that such a provision would not be necessary for very long in the future since liner and corrosion problems experienced in some operations appear to be susceptible to solution with no more ingenuity than the oil industry has shown in connection with many producing problems in the past. However, in order to be conservative in any economic projections at this time, it was decided to follow the basis just described. This gives a total well drilling cost for this hypothetical example of $1,425,000.

Lease operating expense was calculated on the basis of $400 per well-month which takes into account the possibility of unusually high well maintenance costs. This amounts to an annual cost in the range of $45,000 to $50,000 for operation and maintenance of about 10 wells. Again, it would seem that normal development of the in-situ process would certainly result in substantially lower maintenance costs but, in order to be conservative in the

present example, the values indicated were used.

Pumping units were assumed to cost $3000 each with the number of such units being determined by the pattern burning schedule. It was assumed that some of these units could be used several times with proper maintenance; funds were included for workover and reinstallation expense where applicable. A central tank battery to handle an estimated 750 bbl per day was assumed to cost $32,000. This includes heavy duty heater treater equipment but no provisions for recovering light ends from the produced gas.

The price of crude oil was assumed to be $2.50 per bbl.

The operating costs and revenues for this hypothetical commercial operation were considered year by year over the life of the project in a conventional profit and loss type analysis. The effect of taxes, royalties, and other business expense was brought into the analysis in a regular manner and the overall economics for the project were then calculated. A summary of the results is presented below:

TABLE 4. Summary of economics for hypothetical 240-acre in-situ combustion project.

Maximum unrecovered investment (1st yr.)	$ 790,000
Cumulative cash recovery after FIT	$2,900,000
Net profit per W.I. bbl after FIT	$0.61
Payout time	5.8 years
Rate of return	21%

It can be seen from the above analysis that an in-situ combustion project can be a reasonably attractive financial venture even using very conservative cost figures for the operation. As development of the process goes forward, it seems reasonable to expect that ways will be found to lower operating costs, which will, of course, improve these economics. In addition, there are already indications from field tests that oil recoveries higher than 50 percent are possible, which will also have a very beneficial effect on the economics of the process. On the other hand, it should be recognized that the field conditions assumed in this example, while not optimum, are generally favorable for application of the process as we presently understand it. Deeper reservoirs with lower oil content will not be as attractive economically as the example presented above, but even here, it appears possible to go as low as 1000 bbl per acre-ft in oil content, and several thousand feet in depth before the economics of the process become marginal.

In summary, in-situ combustion is a promising new method of oil recovery that has the unique ability of recovering a high percentage of the oil in a reservoir in a relatively short period of time. The economics of the process already appear reasonably attractive under field conditions that exist in a number of areas in the U. S. today. Further development of the process promises to extend its application appreciably to the point at which it could become a significant factor in oil production in many areas.

OTHER THERMAL METHODS

Interest has arisen during the past year in the potential use of thermonuclear energy release as a means of producing oil not recoverable by conventional techniques. The explosion of a 1.7 kiloton atomic bomb 900 ft under the top of a Nevada mesa (Operation Plumbbob) in September of last year,[42] plans to detonate a 10 kiloton bomb in New Mexico salt beds,[43] and some speculation[44] on the use of an H-bomb to recover oil from thick shale beds, such as those in the Piceance Creek Basin, Colorado, represent some of the events which ignited and fueled this interest.

Most encouraging aspect of Operation Plumbbob was the apparent trapping of fission products in fused rock with little likelihood of contamination of ground waters. Less encouraging, from the thermal-energy standpoint, was the rapid dissipation of high temperatures apparently caused by vaporization of formation water. Three months after the explosion no elevation of temperature was noted beyond the crushed zone (a sphere of 130-ft radius), and the highest temperature observed at that time was only some 70 F above the original temperature of the rock. On the basis of information now available, one must come to the perhaps surprising conclusion that the useful mechanical effects of an A-bomb explosion underground are likely to extend to a greater distance than the useful thermal effects.

Other possible methods of heating an oil bearing formation, such as the process of "electrocarbonization," or "electro-linking" tested in recent years for coal gasification[45,46] may become of future economic importance, depending on the cost of energy from various sources. One can visualize, for the distant future, the possibilities of distilling petroleum directly from reservoirs by solar or electrical heating. A similar process is now under commercial development for application to oil shales in Sweden.[47] The very high energy consumption observed in this process (some 900 kwh per bbl of oil produced) may not appear exorbitant in the liquid fuel markets of this country in 2000 A.D.

Acknowledgments

The authors wish to express their appreciation to the management of Socony Mobil Oil Company and Magnolia Petroleum Company for permission to publish this paper. The authors also wish to express their appreciation to General Petroleum Corporation for permission to use certain oil well heating and hot oil injection data used in this paper, and particularly, to T. J. Abshier and K. B. Green of that organization, who assembled and analyzed the field data. In addition, the authors gratefully acknowledge the contributions of C. S. Kuhn of Magnolia's Field Research Laboratory in the preparation of the manuscript, and of G. C. Wallick and G. W. Nabor of the same organization, who collaborated to obtain the numerical solutions on which transient temperature distributions of Fig. 2 were based.

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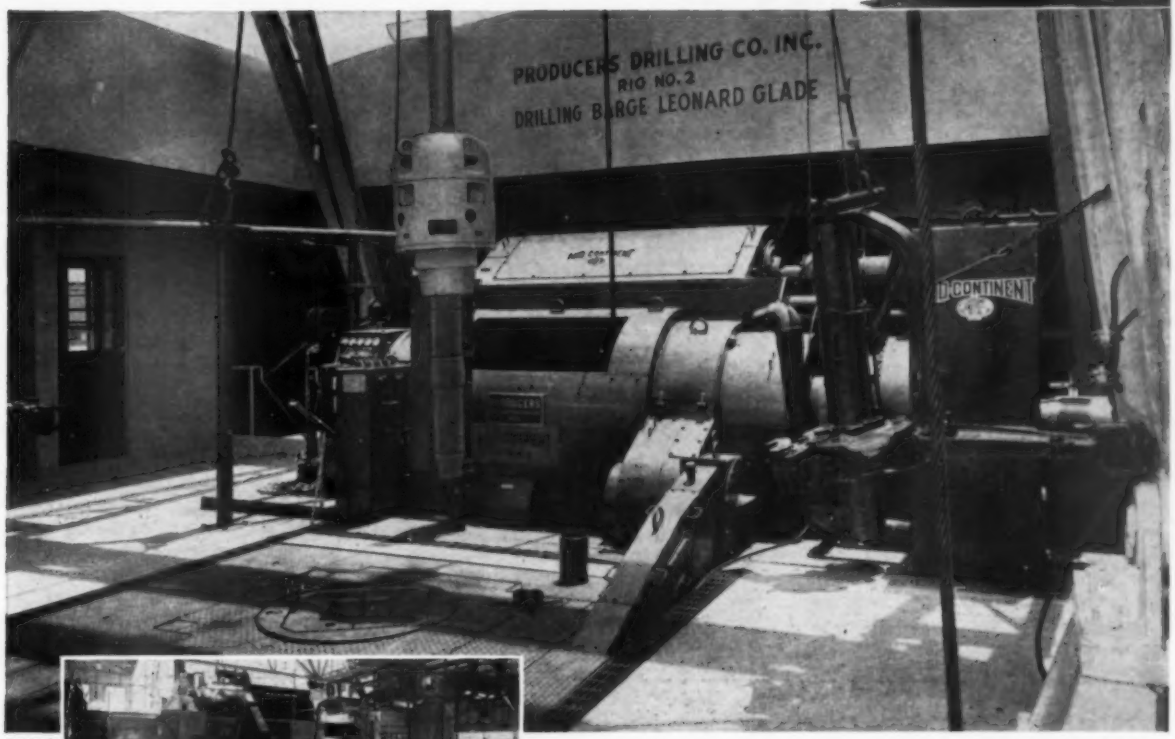

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Chlorine Detection By the Spectral Log

Spectroscopic neutron/neutron and neutron/gamma ray instruments are being successfully used in field tests to detect presence of chlorine — and therefore oil

W. R. Rabson
Manager of Nuclear Logging
Perforating Guns Atlas Corporation
Houston, Texas

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A closer investigation of chemical effects on conventional non-selective types of neutron logs indicated that this feature, detrimental to porosity evaluation of the log, might be useful in identifying formation fluids through differences in their chemical composition. Among the elements present in normal borehole environments it was known that chlorine, one of the elements in NaCl salt, has appreciable effect on neutron log response, second only to hydrogen whose influence is well known. In addition, chlorine is an element not common to the composition of ordinary rock matrix, oil, or fresh water.

Since many possible producing horizons contain a varying combination of salt water, oil and fresh water, a knowledge of the presence or absence of chlorine (in formation water) is therefore indicative of the combined presence or absence of oil and fresh water. In the most common case where the formation is known to contain negligible fresh water (connate or interstitial) the absence of chlorine will suggest the presence of oil.

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(1) Element	(2) Relative effectiveness in slowing down of neutrons	(3) Energy of gamma rays of capture in MEV	(4) No. of gamma rays per 100 captures	(5) Neutron cross section at .025 EV (in barns)	(6) Effective gamma ray intensity (4) x (5)	(7) Atomic weight	(8) Comparative index (6)÷(7)
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Chlorine	5.6	7.77; 7.4	18	32	574	35.46	16.20
Sodium	8.5	3.8	61	.45	28	23	1.22
Oxygen	12.0	—	*	.001	0.0	16	0.0
Silicon	7.0	7.2	9	1.7	15	28	0.54
Phosphorus	6.3	6.8	24	.15	3.6	30.98	.116
Sulphur	6.1	5.4	84	.47	40	32.1	1.25
Potassium	4.8	5.7	18	2	36	39.1	.925
Hydrogen	100.0	2.2	100	.3	30	1.0	30.0
Iron	3.5	7.6	36	2.4	86	55.8	1.54
Nickel	3.4	9.0; 8.6	49	4.5	221	58.7	3.77
Copper	3.2	7.9; 7.6	30	3.6	108	63.5	1.70

*Very small, but not accurately known.

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Consequently, if a spectroscopic type of neutron/gamma instrument capable of discriminating particular gamma ray energies were utilized, it should be possible, by examining only high energy gamma rays, to accentuate the "chlorine effect."

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Development of Instrumentation

The spectrol log instrumentation is actually a highly specialized and compacted laboratory gamma ray spectrometer designed to have high stability with immunity to rough mechanical shock and high borehole temperatures. Early work in the design indicated the need for the spectral selectivity to be controlled from the surface equipment to expedite experimental work. Tests were made which indicated that satisfactory results could not be obtained by transmitting the entire energy spectrum signals up the long (15,000 ft) armored cable for spectral selectivity in the surface equipment because of excessive distortion of the signal by the line. These results clearly called for the development of a borehole instrument capable of discriminating the energy level to be investigated and this level to be controllable from the surface equipment.

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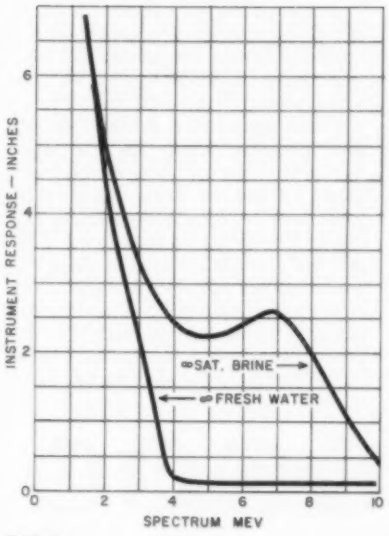
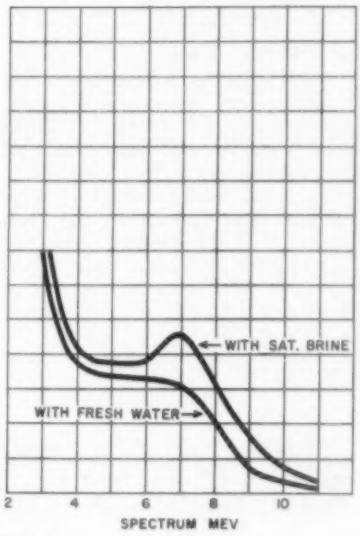


FIG. 1



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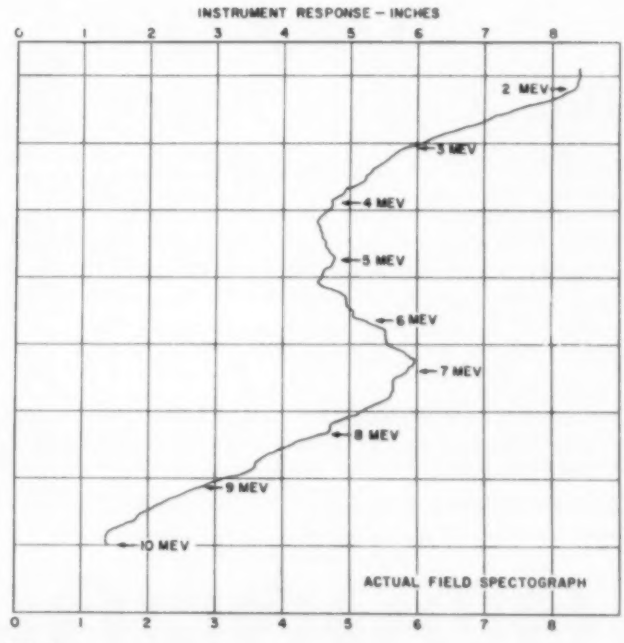

FIG. 3

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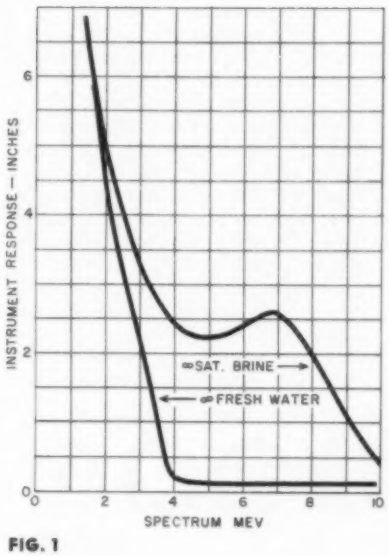

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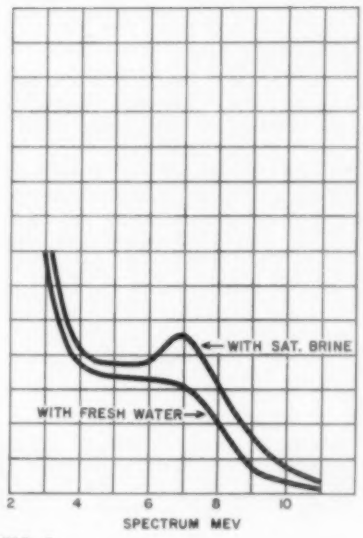

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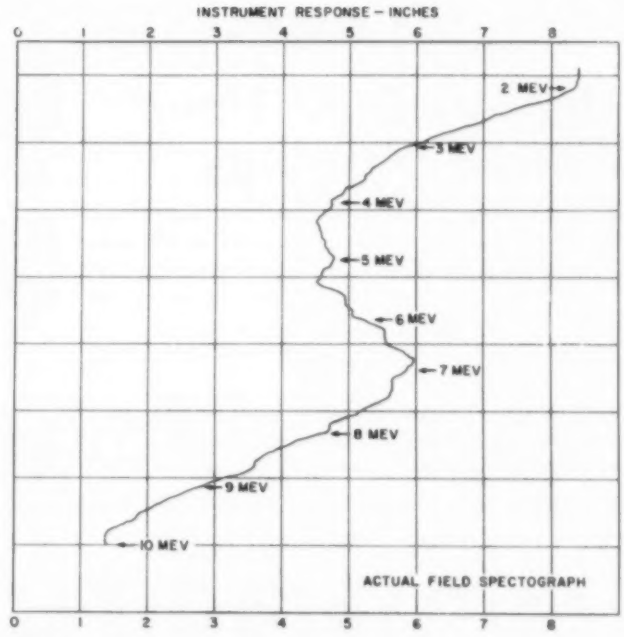

FIG. 3

tron volts (MEV) gamma ray energy.

Laboratory Tests

It is beyond the scope of this article to discuss the voluminous quality of data acquired in laboratory experiments with artificial wells. Much of this work, as previously mentioned, was acquired in the process of developing prototype instruments for commencing field experimental work. The culmination of a large part of this laboratory work is shown, however, in Fig. 1 and 2 in which the fundamental response of the present spectral log instrument to very basic environments is shown.

The spectrographs shown in Fig. 1 depict the instrument response as it is "tuned" through the gamma ray spectrum from 10 MEV to 2 MEV. The lower curve is obtained with the instrument immersed in a large (infinite) tank of fresh water, and the upper curve in a similar tank of saturated brine. Of interest is the almost complete lack of secondary gamma rays above 4 MEV in the fresh water tank, and the pronounced peak at 7 MEV in the brine tank. At 7 MEV the response in the brine tank is 22 times that obtained in the fresh water tank (2.6-in./0.12-in.). This is in contrast to a "chlorine factor" of only 1.2 for a conventional non-selective neutron/gamma instrument under similar test conditions.

The spectrographs shown in Fig. 2 were obtained in the same manner as those in Fig. 1, but in a tank filled with a homogenous mixture of assorted size marble chips representing a limestone formation of about 24 percent porosity. Measurements were first made with fresh water filling the pore space (lower curve). Of particular interest is the effect of the elements present in the marble ($CaCO_3$) which contribute appreciable secondary gamma rays in the range of 4 MEV to 6 MEV, and to lesser extent up to 9 MEV. The chlorine peak is still very evident in the brine curve, but the marked increase in the fresh water curve due to the marble in the 7 MEV range has reduced the chlorine response to only 1.47 times that of fresh water (2.35-in./1.6-in.).

Similar measurements were made in the same tanks with the epithermal and thermal neutron instruments. Chlorine factors for the various instruments are shown below in which chlorine factor is defined as the ratio of response in infinite salt water to response in infinite fresh water. A factor of 1.00 therefore indicates no chlorine effect.

Instrument type	Chlorine factor
Epithermal neutron	1.04
Thermal neutron	—1.93*
Conventional neutron gamma	1.20
7 MEV spectral log	22.0

*Ratio of (inf. fresh water response/inf. salt water response)

From the above it is evident that we have three types of neutron logs, all being predominately sensitive to hydrogen (porosity), but with chlorine effects varying from negative (thermal neutron), to zero (epithermal neutron), to positive (7 MEV spectral log). If all types have identical response to variation in hydrogen content, any differences in response between logs could be attributed to chlorine.

Field Tests

From the previous consideration, first field tests in commercial wells were made in which all three types of logs were run. For analysis the three logs were superimposed and examined for anomalous differences whereby chlorine would be indicated by divergence of the logs; the spectral log increasing in response, and the thermal neutron log decreasing in response with respect to each other and to the epithermal neutron log, unaffected by chlorine.

Some such "separations" of the logs in certain zones were discovered. However, it was evident that inherent differences between the individual logs' response to porosity made the task of

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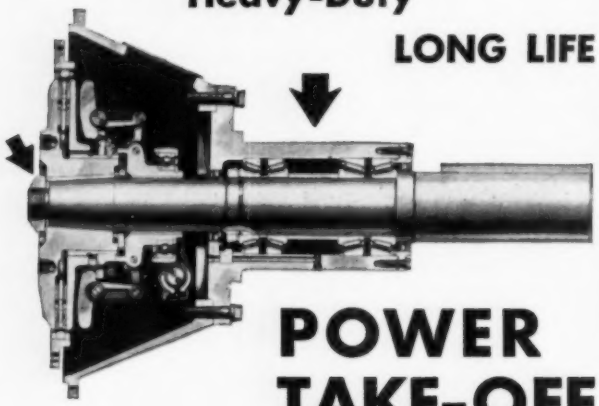

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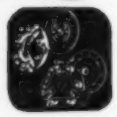

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properly superimposing three logs at all porosity values extremely difficult, if not impossible. Considerable time was also consumed in these early tests in attempting to adjust log sensitivities for comparable amplitude to facilitate examination for chlorine effects.

Partially because of these difficulties in analysis, it was decided to stop the spectral log instrument in particular zones of interest and obtain complete spectrographs of the energy spectrum from 10 MEV down. This is similar to the technique used in obtaining the curves in Fig. 1 and 2.

Such procedure was adopted, and the results immediately confirmed the value of this technique. In many zones spectrographs were obtained having pronounced peaks in the 7 MEV region, indicating the presence of chlorine; and complete absence of such peaks in other zones (usually shales). From this work a standard procedure has been established for commercial use of the spectral log as follows:

1. Acquire a standard epithermal neutron log for accurate determination of formation porosities free from chlorine effects.
2. Log small section of continuous 7 MEV spectral log over zones to be spectrally analyzed. This is useful in establishing adequate depth control of levels to be spectrographed.
3. Run gamma ray energy spectrums with spectral log instrument in all zones of interest. The presence, or absence of a response peak in the 7 MEV region is indicative of the chlorine (salt) content of the interstitial fluid. A typical field spectrum is shown in Fig. 3.

Results: Utilizing the technique outline above, approximately 15 wells in the West Texas area have been spectral logged. Well conditions varied from freshly drilled open holes to 20-year-old cased wells; borehole fluid from fresh water to saturated brine.

It should be mentioned that very grave concern had existed throughout all the preliminary development work as to whether the effect of drilling mud filtrate invasion of the borehole region would displace the native fluids beyond the range of investigation of the nuclear instruments. Especially in limestone formations prevalent in the West Texas area, it is known that invasion of several diameters is common and presents a very pessimistic condition for such work.

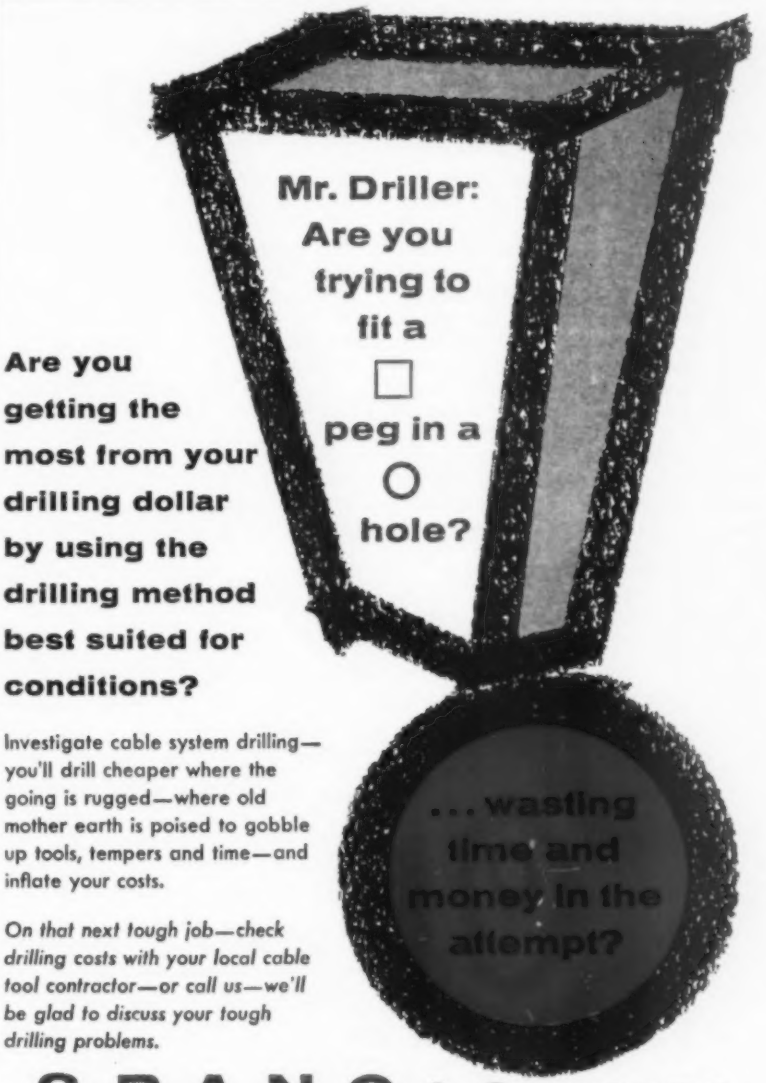
To investigate this effect a comprehensive test was arranged in cooperation with a major oil company whereby all the subject logs would be run on one well at various stages of its completion as follows:

1st. run: Open hole with fresh mud. *2nd. run:* Cased hole, 12 hours after cementing. *3rd. run:* Cased hole, 84 hours after cementing.

This test indicated invasion to be a serious obstacle to obtaining satisfactory results as the open hole logs were practically identical, exhibiting no chlorine divergence. This was apparently due to the fresh water filtrate invading and displacing the native fluids. (Note: Unfortunately, equipment for obtaining the complete spectrographs was not yet available. No spectrographs were obtained in this test.)

Encouraging results were obtained however, in the cased hole condition 84 hours after cementing. This tends to substantiate similar studies of this nature performed by Russian workers who have reported favorable results in chlorine detection by less refined instruments 10 days after casing and cementing the well. Additional data is necessary to determine the optimum time necessary for re-establishment of native fluids in the borehole region. It is believed that in most cases 10 days is adequate, but of course the longer the elapsed time after cementing the better the chance for good results.

Unfortunately many of the 15 spectral logs made to date have not been



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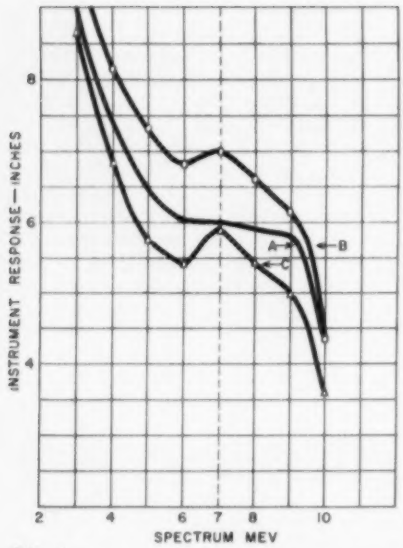

FIG. 4a

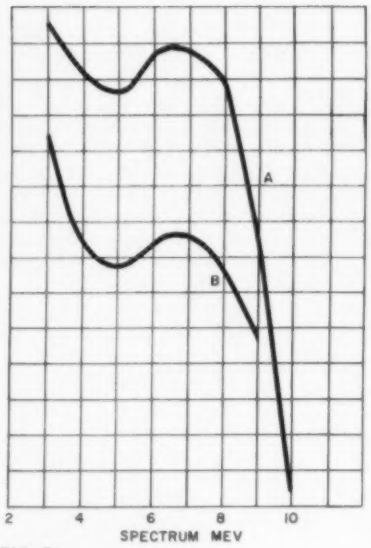

FIG. 5a

conclusive from the standpoint of evaluating its merit. Included among these are logs on approximately 5 wells in which borehole conditions have been established as tentatively not suitable for chlorine detection because of invasion effects. (Two logged in open hole, and 3 immediately after cementing of casing.) Two wells were logged with saline borehole fluids in the casing which tends to disguise any effects from the formation fluids.

Of the remaining 8 wells, apparently good results were obtained as chlorine peaks are present in many spectrographs, but in 5 wells no definite knowledge of fluids in the zones analyzed is available. There remain 3 wells in which borehole conditions were proper and reasonably accurate information available as to fluids present. These are presented as examples of the performance of the spectral log in distinguishing the presence of chlorine.

Example Log 1: (Fig. 4b)

Illustrated here are the 7 MEV spectral log (solid line) and the standard epithermal neutron porosity log (dashed line) run in a well in Gaines County, Texas. The logs were made 7 days after cementing 5½-in. casing in 7⅞-in. bore hole. Borehole fluid is oil.

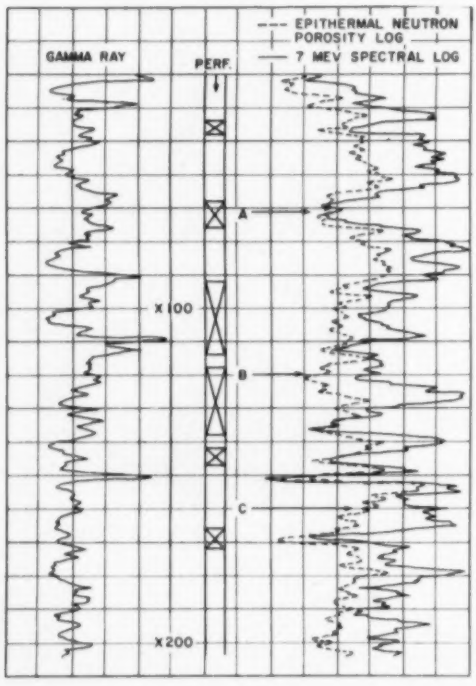

FIG. 4b

Spectrographs shown in Fig. 4a were made at three levels designated A, B, and C. The spectrographs confirmed the continuous logs, with pronounced peaks in the 7 MEV region evident at levels B and C, where the continuous logs reveal separation. The spectrum at level A is devoid of the 7 MEV peak, indicating no chlorine present which is confirmed by the continuous logs with no separation at this level.

The well was perforated in the zones shown and flowed 24 bbl of oil and 98 bbl of salt water per day. Unfortunately the zones were not individually perforated and tested, but the overall results substantiate that predicted from the spectral log.

Example Log 2: (Fig. 5b)

Shown here are logs made in a 10,000 ft well (drilled 1947) in Ector County, Texas, with 5½-in. casing set in 7⅞-in. bore hole filled with fresh water. Spectrographs (Fig. 5a) were made at two levels A, and B, in a large zone known to carry salt water. The pronounced peaks in the 7 MEV region confirm the presence of chlorine, as do the continuous logs by their separation in this zone.

The effect of porosity on the degree of separation between logs when chlorine is present is clearly shown in this example. Zone A being less porous than Zone B (shown by the neutron porosity log) contains less salt water which therefore accounts for less accentuation of spectral log response in A than in B. The effect of porosity is also shown by the spectrographs in their relative position to each other; with lower porosity causing progressively higher overall response than more porous zones. Of interest also is the lack of separation in the chlorine

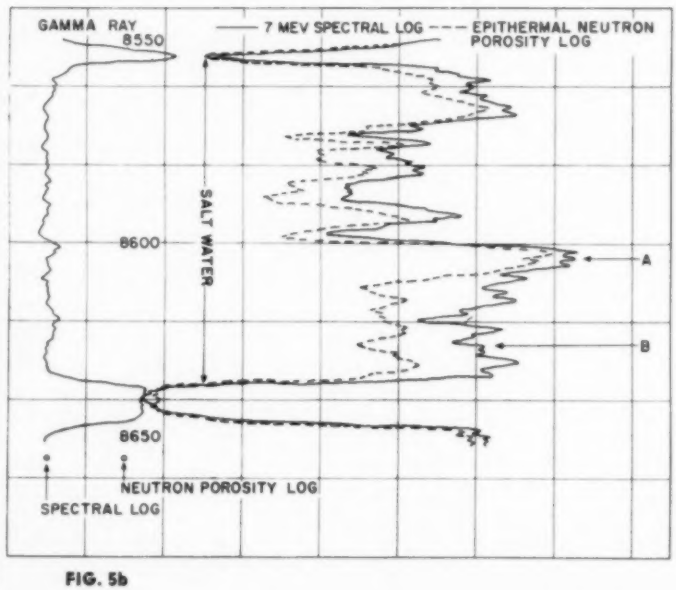

FIG. 5b

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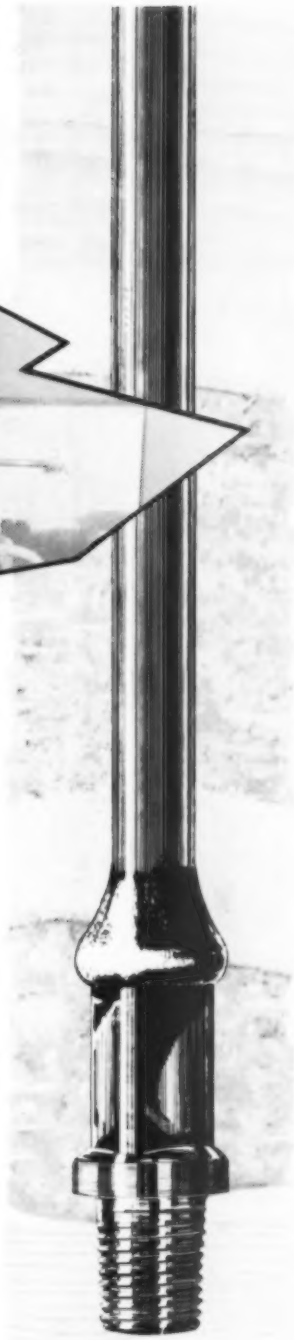

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Through the years, Hughes has introduced virtually every major improvement that has been made in rock bits. But no single achievement has had greater impact on rotary drilling than that first rock bit run at Goose Creek in 1909.

In the painting at the left, the artist has re-created the scene of the running of the first rock bit. So important was secrecy that members of the drilling crew were ordered from the rig, and their places taken by Mr. Hughes and his three companions. Then, Mr. Hughes opened a padlocked wooden box, lifted out a burlap-wrapped bit, attached it to the end of the drillstem, and pulled the wrapping away as the bit was lowered into the hole. When it was safely out of sight, the crew was called back to resume drilling.

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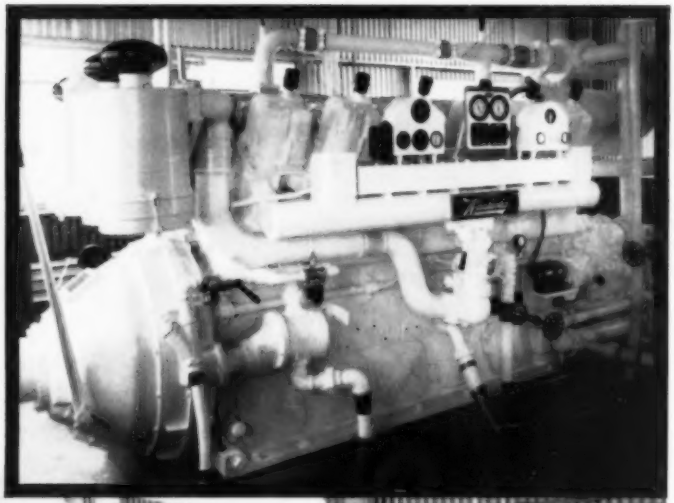

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— free shales at 8550 and 8640 ft. Several other zones in this well were spectrally investigated, but testing and completion of this well is still forthcoming.

Example Log 3: (Fig. 6b)

In this case a comparison is shown between the 7 MEV spectral log and the thermal neutron log with opposing chlorine effect. This well, also in Ector County, was drilled in 1948 and was logged in 5½-in. casing in 7⅞-in. bore hole filled with fresh water. Spectrographs (Fig. 6a) were made in the four zones, A, B, C, D, confirming the continuous log results and the fact that Zone X is known to be an oil bearing dolomite, Zone Y salt bearing limestone, and Zone Z oil bearing.

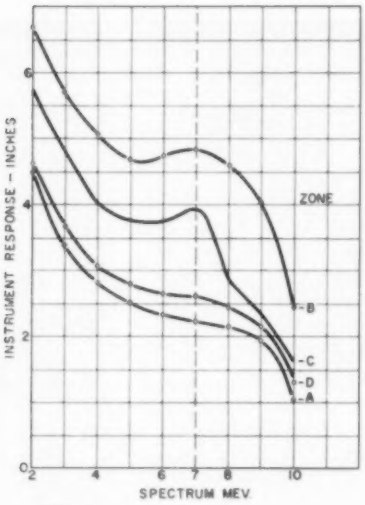


FIG. 6a

Conclusion

Examples have been shown in which spectroscopic instruments of the neutron/neutron and neutron/gamma types may be used for detecting the presence of chlorine, and therefore oil (by the absence of chlorine) under certain borehole conditions. In this regard additional work is necessary to determine exactly what hole conditions are necessary for satisfactory interpretation of the logs. It presently appears that best results in chlorine detection are obtained in cased holes logged at least 10 days after cementing. This is of great importance in providing a method of re-evaluating old wells for missed oil-bearing zones, and following the movement of oil/water interfaces.

It is believed that valuable information is contained in the shape of the spectrographs whereby certain elements constituting the formation matrix may be identified. Already, distinct differences in the spectrums in the 8 and 9 MEV region are apparent but not well understood. It is even possible that gas-bearing zones will be identifiable through the use of spectral logs in conjunction with conventional neutron logs.

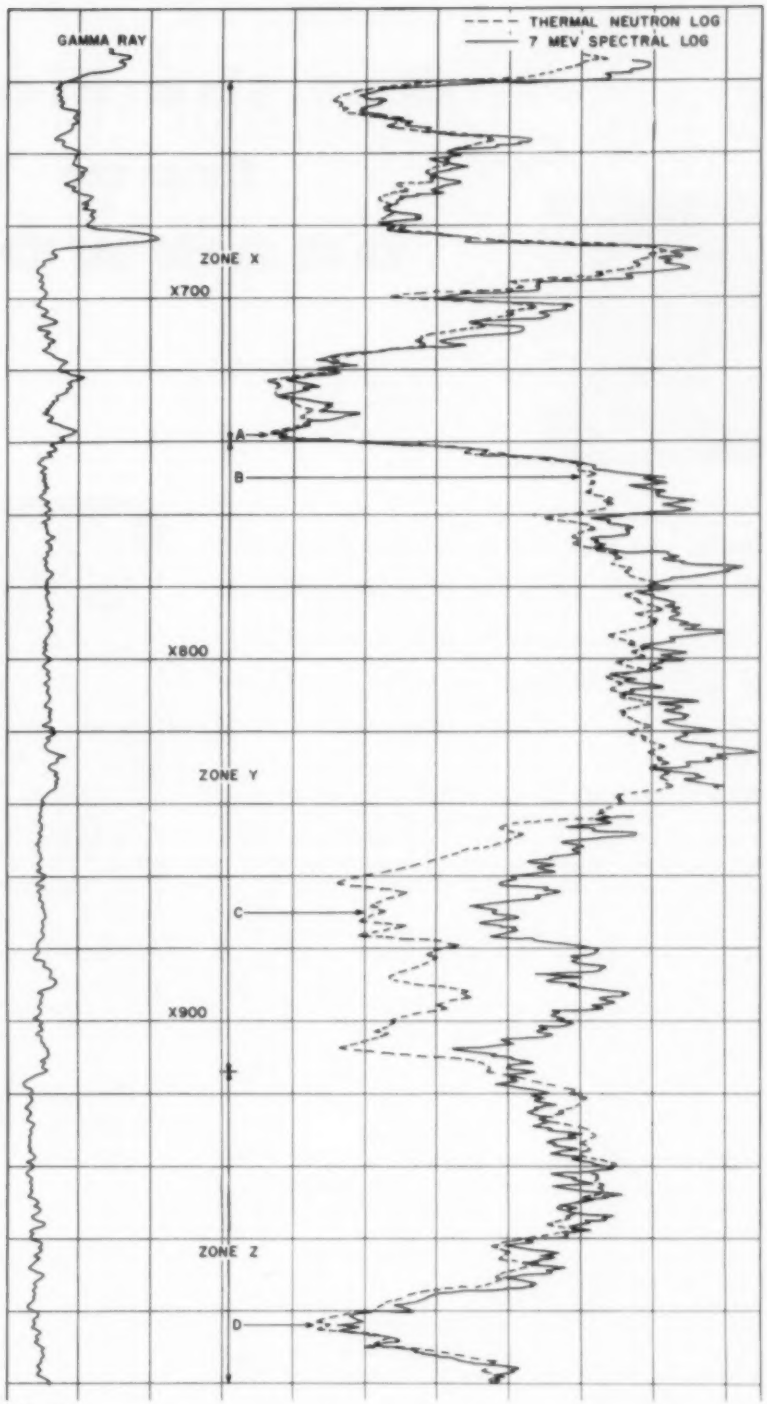


FIG. 6b

As with all new well logging methods, the real merit of the spectral log technique cannot yet be fully determined. Its performance to date has been highly successful, leading to the construction of additional field units. This will accelerate evaluation of the logs' usefulness in many different areas and borehole conditions. In this respect the author is already indebted to several of the major oil companies in providing wells and information for this study. ★ ★ ★

Get the Most from Your DRAWWORKS

Jack Marsee, *Chief Engineer*
Lofland Brothers Company
Tulsa, Oklahoma

Initial cost and power rating tell only part of story of rig evaluation; mechanical factors, service conditions and acceptibility of service obtained must be considered

NO ONE associated with the drilling business need be reminded that economically these are trying times. For this reason, an opportunity to improve the utilization of equipment must not pass without consideration. It is the intent here to present information that will assist in achieving better selection and use of drawworks.

Improvements in drilling technology have resulted from increases in application of engine and pump horsepower to drilling procedure. The result of attention being thus focused on engines and pumps is that their selection and use has been reviewed thoroughly in meetings of technical groups and in the trade literature.

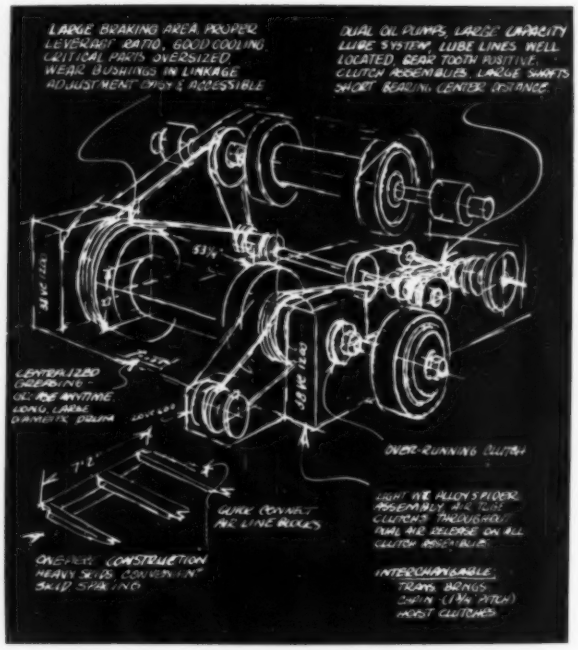
Let us not forget the drawworks, only slightly less important as an item of rig equipment, which is also deserving of study.

Understand Drawworks Ratings

The rating given drilling equipment is often misunderstood, which frequently results in misapplication and failure to achieve optimum performance. The rating given *any* equipment depends upon mechanical factors, service conditions, and the acceptability of the service obtained in any particular type of competitive use. The mechanical elements that constitute machinery have been with us for a number of years so that it is possible through observation of past service, to know how any particular element will respond to usage circumstances.

Equipment rating includes consideration of the mechanical factors in the equipment in relation to the service that the owner should expect from usage he will give it.

Mechanical considerations. To understand this more clearly, take for example internal combustion engines. Engines used for aircraft service must be light in weight. When rated power output is taken from the engine various parts are experiencing comparatively severe service and the result is that it is normal and accepted that an aircraft engine will be disassembled for certain repairs after every 100 hours usage.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DUAL OIL PUMPS, LARGE CAPACITY LUBE SYSTEM, LUBE LINES WELL LOCATED, GEAR TOOTH POSITIVE CLUTCH ASSEMBLIES, LARGE SHAFTS SHORT BEARING CENTER DISTANCE
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The other extreme, as compared to drilling engines, is the stationary type of engine which is of extremely heavy construction in relation to the horsepower output. Because the comparative service is mild, these engines are expected to run for years without significant repairs.

Thus, three engines — one for aircraft, one for drilling, and one for plant use, might be rated at the same horsepower output, but certainly one would not be acceptable in the field of use assigned the others.

These are extremes of service variations but the illustration is valid to a very considerable degree concerning engines to be applied to the same type of service.

Service conditions. Another important consideration in establishing rating is in regard to the nature of operation of the equipment. The past few years has seen improvement in the operation of drawworks that eliminates abuse that was more or less accepted a few years ago. With the elimination of this abusive operation, it was learned that many of the older drawworks would function satisfactorily at work that

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TABLE 1. Transmission Chain Speed Allowables at 453 rpm Input.

	Number of Teeth on 1¾" Pitch Sprockets		Radius at Pitch Line, Inches	Allowable rpm	Actual rpm
Driver	Hi-	25	13.963/2 = 6.981	950	453*
Driver	2nd-	20	11.187/2 = 5.593	850	"
Driver	Lo-	20	"	850	"
Driven	Hi-	20	"	850	566†
Driven	2nd-	25	13.963/2 = 6.981	950	...
Driven	Lo-	36	20.079/2 = 10.039	900	...
Driver	Hi-	40	22.305/2 = 11.152	800	566**
Driven	Hi-	49	27.314/2 = 13.657	600	462
Driver	Lo-	20	11.187/2 = 5.593	850	566**
Driven	Lo-	87	48.472/2 = 24.236	Less than 400	130

Rotary Drive	No. of Teeth	Radius at Pitch Line, Inches	Allowable rpm	Actual rpm
Driver	49	27.314/2 = 13.657	600	462
Driven	34	18.966/2 = 9.483	900	666

* At 453 rpm input.
† Maximum for shaft because other sprockets are clutched.
** Maximum

was far in excess of the manufacturer's original intent. For many years contractors deliberately underpowered drawworks because they had in mind that if sufficient power was available that drillers would keep the drawworks torn up.

Then it became recognized that the underpowered drawworks cannot be operated competitively and still achieve low maintenance cost. When an engine is overloaded it will never achieve maximum speed during the hoisting of a stand of drill pipe, if the drawworks clutch is engaged while the engines are idling. Now, most drillers are eager to make a good showing and it's too much to expect a driller that is operating a drawworks that is so rigged, to put up with the slow hoisting time that is the result. So it's fairly certain that a driller on an underpowered drawworks will feel compelled to accelerate the engines before engaging the clutch.

This is the most significant factor affecting the performance that can be obtained from a drawworks. The faster the drawworks shafts are turning when the hoisting clutch is engaged, the greater the shock loads will be on chains, shafting and bearings. The hoisting clutch itself experiences considerable damage because slippage increases as the relative speed of the clutch to the drum increases. This causes the friction surface of the clutch to heat and the heating increases the tendency of the clutch to slip, thus the situation compounds itself to hasten the destruction of the clutch.

From these facts the basic rule for optimum drawworks performance becomes evident: Engines must be at the slowest possible speed when the clutch is engaged. General acceptance of this basic rule is the principle factor that has affected the manner of rating a drawworks.

Reasonably diligent maintenance on the part of operating personnel can be assured by the manufacturer if his design is such that parts which need attention are readily accessible to the crews. Since service considerations are an important part of rating, it is highly essential that a drawworks be so designed as to lend itself to easy maintenance. Otherwise sound structural design may give poor service as the result of inadequate preventive maintenance and daily care.

Mechanical Factors of Drawworks Rating

The mechanical factors that establish the upper limit of drawworks rating are chain speeds and load, clutch capacity, bearing speed and load, shaft diameter and distance between bearings, and wire line speed.

Satisfactory chain performance has been obtained at speeds that are nearly double the values published in chain manufacturer's general use catalogs. The result is that chain manufacturers now publish special oil field design information that is consistent with information established by field usage. Where this information is not available, the information shown in chain manufacturer's general use catalog will be acceptable if speed values are doubled.

The design load for chain is ⅛ of the ultimate strength.

Clutch capacity is usually taken in accord with manufacturer's published ratings.

Wire line speed is a somewhat relative value which represents a maximum usable speed established by the mechanical dexterity of drillers and crews. Observation of rigs in use has established that a drawworks which runs faster than a maximum line speed of 4100 ft per min, cannot ordinarily be operated in a manner that will result in additional time saving.

Chain and clutch capacity and wire line speed measurement is information which is readily available to the user and the nature of the use of these factors is so simple that it is reasonable to expect a user to understand how these factors limit the rating of a drawworks. Bearing speed and loads, and shaft diameter and the distance between bearings, are factors which are pertinent to the rating of a drawworks. The detail of the engineering involving these factors is somewhat complicated so that if examination and comparison to equipment of established performance justifies analysis of these factors, the user will probably have to rely on the manufacturer for detailed information. In every instance the design is such that the chain and clutches are the expendable elements in a drawworks and their service life is a fractional part of the design life of bearings and shafting. Thus, ratings can be calculated from limitations imposed by chains, clutches, and wire line speed.

Limiting Factors in Determining Rating

To develop a general drawworks rating formula, let's analyze a specific drawworks. The following is an analysis of a well-known middle to deep drilling rated rig. Its rating is based on revolutions per minute limited by line speed maximum at 4100 ft per min, chain loading at ⅛ of ultimate, and clutch capacity in accordance with published values. Mechanical losses are calculated at four percent per shaft. Dimensions are from manufacturer's catalogs.

Line Speed Calculations:

	1st layer	2nd layer	3rd layer
Bare drum radius	13.5 in.	13.5 in.	13.5 in.
+ layer build-up	1.11 in.	2.29 in.	3.48 in.
	14.61 in.	15.79 in.	16.98 in.
Perimeter	7.66 ft	8.26 ft	8.89 ft
Line per layer	192. ft	314. ft	338. ft

w/8 lines spooled and 98 ft per stand, 8 × 93 ft = 744 ft spooled in hoisting each stand.

So, since 744 ft is less than the amount spooled on three layers but more than on two layers, the third layer is where maximum line speed will occur.

At 4100 fpm limit:

$$\frac{4100 \text{ fpm}}{8.89 \text{ ft}} = 462 \text{ rpm at the drum}$$

So the input rpm would be:

$$425/434 \times 462 = 453 \text{ rpm}$$

Conclusion: Since allowable speeds are considerably in excess of actual speeds, an input shaft rpm of 453 is satisfactory.

Input Torque Calculations

Clutch Capacity: Both large drum clutches are 38-in. ventilated element air clutches, rated at 680,000 in.-lb.

The clutch is thus rated to handle the following chain loading to the drum shaft.

$$\text{Low Side} - \frac{680{,}000 \text{ in.-lb}}{24.236 \text{ in.}} = 28{,}100 \text{ lb}$$

$$\text{High Side} - \frac{680{,}000 \text{ in.-lb}}{13.657 \text{ in.}} = 49{,}800 \text{ lb}$$

The chain is 1¾ in. pitch, quad. having an ultimate strength of 184,000 lb, so the design load is $\frac{184{,}000}{5}$ = 36,800 lb.

Thus, the low clutch is established as the limiting member of the low drum drive because of the limit of 28,100 lb chain pull that it can transmit. There are at least two facts that are to be considered in appraising this limitation.

1. This clutch capacity will develop 40,100 lb single line pull which is slightly in excess of design working limit of even VHS wire line.

   $$\text{Single line pull} = \frac{680{,}000 \text{ in.-lb}}{16.98 \text{ in.}} = 40{,}100 \text{ lb}$$

2. With eight lines strung, 274,000 lb hook load can be handled in third gear, so far as clutch limit is concerned. This is good performance for a drawworks in this class.
   Hook load w/8 lines = 40,100 lb × 8 × .852 = 274,000 lb
   (based on 98 percent per line efficiency)

So load calculations thus far, based on the clutch capacity limit, have established that chain loading to the high side of the drum can be 36,800 ft, (chain limit) and to the low side 28,100 lb, (clutch limit) and drum torque is: High—13.657 in. × 36,800 = 503,000 in.-lb and low, 680,000 in.-lb.

Moving back to the input shaft, with chain loading limited to 36,800 in., the torque that the *Lo* and *Second* transmission drive sprocket can transmit is:

$$5.593 \text{ in.} \times 36{,}800 \text{ in.} = 206{,}000 \text{ in.-lb}$$

and *High* is:

$$6.981 \text{ in.} \times 36{,}800 = 267{,}000 \text{ in.-lb}$$

For the *Low Drum Drive* we have established that both the practical and design limit of drum torque can be obtained in third (high trans.—low drum). So the input torque required to reach the capacity of the *Low Drum Drive* (using a mechanical efficiency of 96 percent of shaft) is:

$$680{,}000 \text{ in.-lb} \times 122/425 \times \frac{1}{.92} = 210{,}000 \text{ in.-lb}$$

which is less than the 267,000 in.-lb that hi transmission can transmit, so the limit of *input to high* transmission, for use by *low drum*, is 210,000 in.-lb.

For the *High Drum Drive* we can use the following input torque:

Through *Transmission Second:*

$$503{,}000 \times 277/425 \times \frac{1}{.921} = 355{,}000 \text{ in.-lb}$$

which is more than second transmission chain can stand—so second transmission chain limit is maximum, or 206,000 in.-lb is the maximum allowable input torque.

Through *Transmission Low:*

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all drives . . .

with all power sources

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SWP-11

$$503{,}000 \times \frac{192}{425} \times \frac{1}{.921} = 246{,}000 \text{ in.-lb}$$

which is also more than Lo transmission chain can stand—so Lo transmission chain limit is maximum, or 206,000 in.-lb.

Summary of Conclusions: The maximum input torque is 210,000 in.-lb to high transmission.

The limit of torque to second and Lo transmission is 206,000 in.-lb.

Input Horsepower Calculation:

Input *Shaft* rpm has been established at 453 rpm.

Input *Torque* has been established at a practical *maximum* of 210,000 in.-lb.

$$\text{Horsepower} = \frac{\text{rpm} \times \text{torque}}{63025}$$

$$= \frac{453 \times 210{,}000}{63025} = 1510 \text{ hp}$$

The manufacturer has rated this drawworks at a maximum of 1400 hp. If we confine the input shaft rpm to their maximum of 425 and use the *average* of torque values calculated above:

$$\text{Horsepower} = \frac{425 \times 208{,}000}{63025} = 1400 \text{ hp}$$

Selection and Application of Engines

Assuming that it is concluded that the appropriate horsepower input to this drawworks should be 1400 hp, as indicated by the manufacturer:

$$\text{Torque} = \frac{1400 \times 63025}{425} = 208{,}000 \text{ in.-lb}$$

If the upper limit of hook loads for each speed range is to be handled, the engines must develop sufficient torque at idling speed to handle the above value.

This will usually result in the application of engines whose *combined rated horsepower at maximum continuous speed is considerably in excess of 1400 hp.*

The reason is that one must plan to offset the many power losses that occur, as well as recognize that engine idle-speed torque capacity is less than at maximum speed.

If 1050 rpm is to be top engine speed, the compound output torque will have to be:

$$\text{T—}208{,}000 \times 425/1050 \times \frac{1}{.96} = 87{,}500 \text{ in.-lb}$$

Thus, the combined torque capacity of the engines, *after* taking into account the mechanical losses in the compound and losses in engine output due to elevation, temperature and general state of wear, must be 87,500 in.lb if the drawworks is to achieve optimum performance.

Other Factors in Rating

It has become the custom to give drawworks dual rating values. For example, one manufacturer assigns model numbers such as 712, 914, 1220, to their drawworks. This dual rating has no direct relation to the mechanical structure of the drawworks, as has been demonstrated, but it is quite appropriate in other respects. If a drawworks is designed so as to move and rig-up readily, if it is constructed so that it is easy to repair and maintain, if operating characteristics are such that the user isn't penalized in applying it at less than maximum capacity holes, then a figure that defines the lesser limit of application is quite appropriate.

Selection of Drawworks:

The mechanical elements within a drawworks are of course the most important when drawworks selection is be-

ing made; but other features contribute to general acceptability and value.

The contractor wants a structural arrangement that will move and rig-up rapidly, so the entire assembly should, if possible, be mounted on a single skid. Smooth engagement and quick release of clutches minimize the physical effort required of the driller and will contribute to safer trip making.

Ready response and release of the brake also contributes to ease of operation. The increase in block-fall time that results from dragging brake blocks contributes needless loss of time as well as extra maintenance cost.

The greatest point of wear on the drilling line occurs where the line crosses over from one layer to the next, so the drum should be sized so as to minimize these crossovers. Also, drum diameter has a direct bearing on block fall time: The weight of the traveling equipment creates the line pull that accelerates the drum, the drum radius being the lever arm in the force system creating acceleration, so good block fall time dictates that the design shall have a minimum of mass in rotation as the blocks are falling.

Good lubrication of bearings and chain is important and there's more to this than simply providing enough pump to circulate an adequate volume of oil. Guards must be oil tight, of course, but they must also be easily removed and replaced, and so constructed that if a chain breaks, major repairs to the guards aren't required to fix the damage. The lines which carry the oil must be so situated and protected than a broken chain won't destroy the lube system.

Repair of the plumbing for cooling the drum flanges is a major project on some drawworks. Also, line sizes on some are such that a little accumulation of scale will restrict cooling water flow so that brake cooling is inadequate.

Obviously there are many other things on the list of features that when added to the mechanical aspects of the design, determine the total value of the drawworks. These things add to the manufacturer's cost because of engineering, manufacturing costs, and materials, thus a buyer must recognize these features and examine them in light of what they'll mean to his use; a mere price and rating comparison could easily result in disappointment. When the length of service that must be obtained from equipment is considered, those features that contribute to low operating cost and customer acceptability become doubly important.

Conclusion

The rating of a drawworks is a fairly accurate representation of what the drawworks can do, but it is the result of consideration of the response of the mechanical elements to the care and usage that it will be given, and the acceptability of performance that is likely to be achieved by anticipated care and use. Thus, rating isn't an absolute value and the validity of the rating is to a considerable degree dependent on the user.

The most profitable usage of equipment will result from understanding the mechanical factors on which the drawworks rating is based, and so rigging and operating the drawworks to take advantage of the potential of one element without hastening the destruction of another.

A drawworks may be technically sound but still have certain features that seriously diminish its value from the standpoint of operating cost and general acceptability. Selection of a drawworks should be based on evaluation of these features as well as on initial cost and power rating.

Acknowledgment

The material contained here was adapted from an article by the same title by this author in *Drilling Is Our Business*, Vol. 2, No. 1, magazine of the Loffland Brothers Company, who granted its publication in *The Petroleum Engineer*. ★

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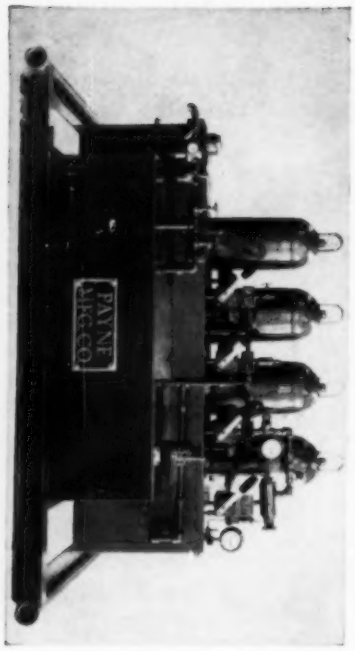

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Bureau Takes '58 Oil Census

CONGRESS passed a bill in 1954 for a census of mineral industries, with the idea of showing the extent of our resources and how they were operated. The first census was taken in that year.

This year is a new census which will cover operations during the calendar year, 1958, and in general the inquiries will be the same type as those made in 1954.

Report forms were mailed in January of this year to all establishments in the minerals industries which employed paid personnel in 1958, as well as to establishments operated by proprietors or contractors.

In the oil industry there are five forms:

MC-13A—Crude Petroleum and Natural Gas,

MC-13B—Natural Gas Liquids,

MC-13C—Oil and Gas Field Services,

MC-13D—Oil and Gas Field Operations,

MC-13X—Offshore Oil and Gas Operations.

There are also short forms for smaller operators which contain fewer inquiries than the long forms. Two of these are MC-13S-1 entitled Oil and Gas, and MC-13S-2 for Oil and Gas Field Services.

MC-13X, the Offshore Oil and Gas Operations form is a supplement to the long form MC-13A.

Many of the questions in the 1958 report forms are standard inquiries about name and location of establishment; company organization; form of ownership; employment and payrolls; man-hours of production and development workers; costs of supplies; products for resale; value of shipments; and capital expenditures. Some of the questions may be answered simply by placing a check mark in a box; others will require compilation of statistical data generally available from company records.

Forms are to be returned to the Bureau of Census not later than 30 days after receipt.

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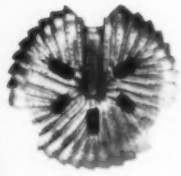
DIAMOND DRILL BITS
Patent applied for
HYCALOG

ONE BIT DRILLS 1206 FEET IN 15,000 FOOT HOLE



In a South Louisiana well, recently completed, a single $5\frac{15}{16}$" Hycalog V-Door diamond drill bit made the run through sand and shale from 14,324 feet to 15,530 feet. No trips out of the hole were necessary for bit changes and the run was completed in 247 hours at an average drilling rate of 4.8 feet per hour.

When pulled, after reaching the total depth, the bit was found to be in excellent condition and *capable of making a lot more hole.*

This is just one of a number of such records set by Hycalog V-Door bits. Why not let V-Doors set a record on your next drilling program? *And ask us also about Hycalog* GAS CHRONOFRAC *well logging services.*

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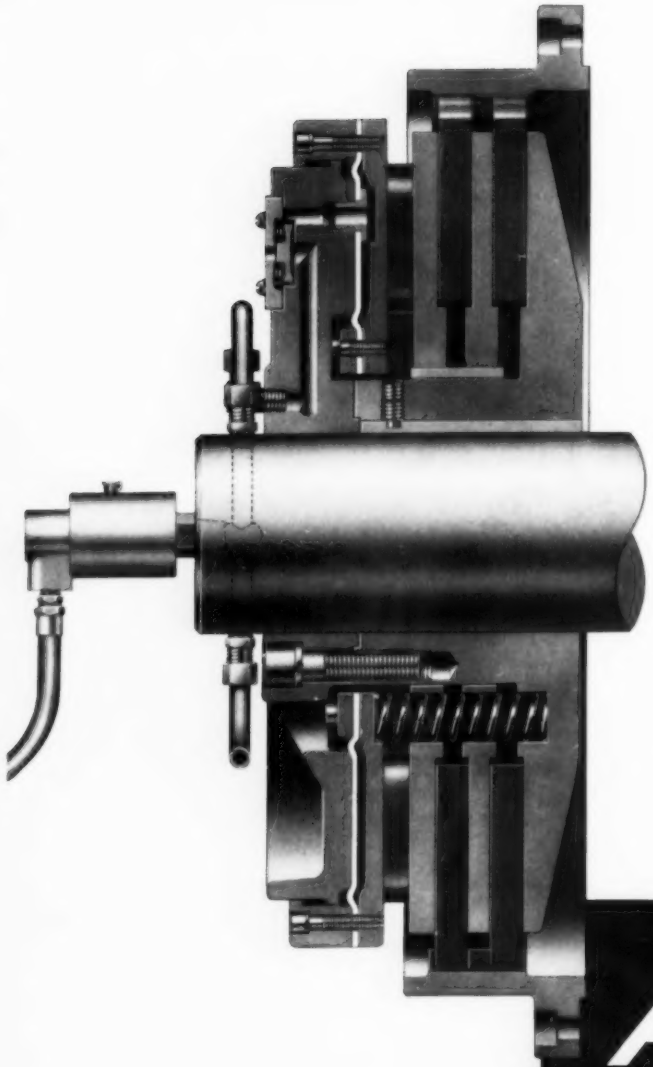

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10. Available from stock in single and double plate types. Capacities from 8.5 to 460 hp at 100 rpm at 80 psi.

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WORLD'S DEEPEST WELL:

Plugged and Abandoned

Phillips' No. 1-EE University — 25,340 ft of dry hole that has produced a wealth of new deep drilling tools and practices, geological knowledge, and a challenge to oil equipment manufacturers and service companies

C. R. Graham,
Assistant Editor

PHILLIPS Petroleum Company's No. 1-EE University has been officially written off as a failure in the company records, but written into the industry record books as a whopping success.

The 25,340-ft wildcat in Pecos County, Texas, holds the record as the world's deepest drilled hole; as having the world's deepest fishing job; as having the world's deepest whipstock; drilled for a long period the world's longest section of open hole; world's longest casing string; world's deepest cementing and perforating jobs; world's deepest successful drillstem testing . . .

Nevertheless, Phillips put a "plugged and abandoned" stamp on the well and has stacked the company's now-famous Rig 27. The large rig spudded the No. 1-EE University in Section 7, Block 24, University Land Survey, on October 12, 1956. It is located on the treeless prairie about 11 miles northeast of Fort Stockton.

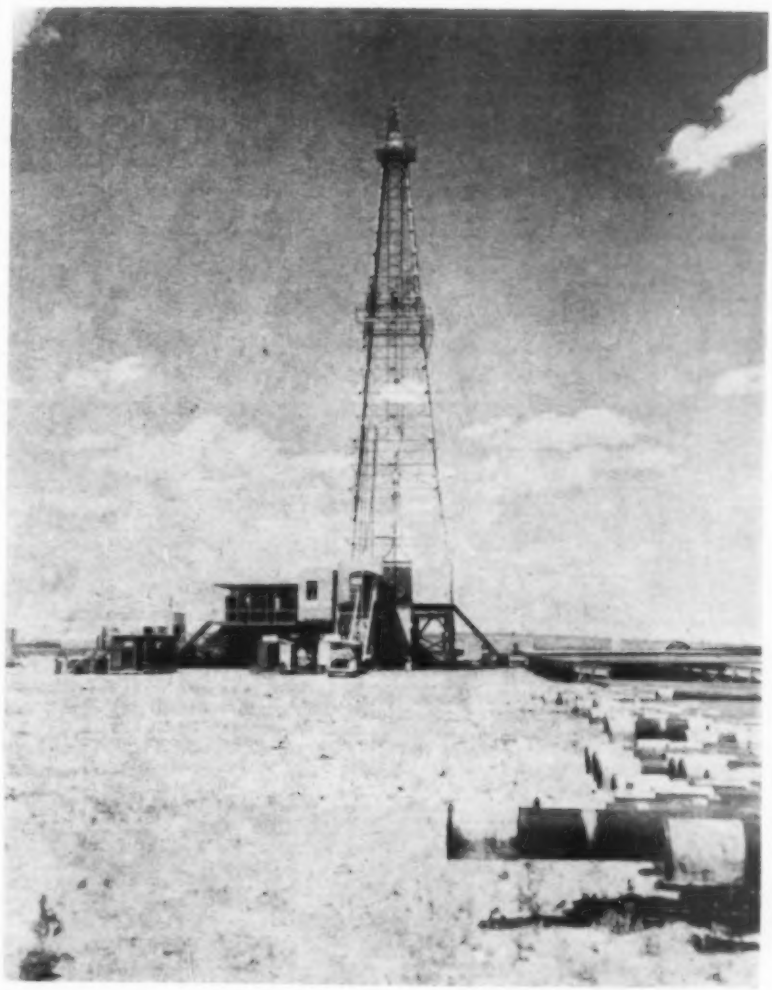
The well began to attract attention on April 28, 1958, when it broke the Texas depth record of 21,687 ft. Less than a month later, on May 26, it broke the world's depth record of 22,570 ft.

The previous world's record was set in South Louisiana at Richardson & Bass' No. 1-LL&E in 1955.

For the most part, the operation might be considered "smooth."

Drillpipe Lost

The No. 1-EE went to a depth of 21,396 ft without trouble, then lost 39 stands of drillpipe. The fishing job that followed consumed 90 days early in 1958. Phillips backed off and set the deepest whipstock on record at 19,986 ft. From that point to 25,340 ft the well was drilled in sidetracked hole.



Phillips' Rig 27, in the background, put to rest over 1,000,000 lb of casing into the dry hole, No. 1-EE University.

Out of Adversity . . .

This was the only major trouble experienced in the two years and four months at the No. 1-EE location. But from the loss of drillpipe a new technique was developed for handling long strings of high tensile strength necessary to drill today's four-to-five mile deep wells.

Phillips' engineers and metallurgists found that the loss of drillpipe was due to parting at the point of slip-segment contact.

It was then that Phillips decided that drillpipe slips could no longer be used in the deeper portions of their deep-deep wells.

After some experimentation, the company constructed a shock-absorbing steel table consisting of two slotted steel discs separated by six hydraulic rams and four steel guides. This was found to successfully lessen pipe fatigue and lighten the impact while making up and breaking out the long section of high tensile pipe that was the upper portion of the drilling string.

To eliminate the slip-dog bites that were inherent with the 300,000 lb drillpipe loads and 375,000 lb dead weight loads up to 375,000 lb, Phillips added another new practice in drillpipe handling.

The use of two sets of elevators was adopted on Rig 27, and has since been

No failures here! Smiling is rig superintendent Ray Jackson, who called the rig's bunkhouse "home" for 28 months, and H. W. Patterson, drilling superintendent for Phillips Petroleum Company, Bartlesville.

adopted as standard practice on rigs drilling other deep wells in West Texas and Oklahoma. The dual elevator system, too, is used only while working with high strength pipe.

Dual Elevator Procedure

After the shock absorber table is swung into position over the rotary table and around the drillpipe, the first stand of pipe, held by the first set of side-door type elevators, is pulled. The second set of elevators is fastened around the pipe below the tool joint, then brought to rest on the hydraulic table. The pipe is broken out with conventional tongs and the first stand is racked. The first set of elevators, empty, is returned to the table and links transferred to the second set and the second stand is pulled. The initial elevators ready to be slid into position around and just below the top box joint of the third stand. After the high tensile strength pipe has been pulled and the drillpipe load lessened, the second set of elevators and the hydraulic shock table are moved away from the rotary table and replaced by hydraulic slips to pull the remainder of the string.

This unique treatment of high tensile pipe is now used on several other deep wells. Phillips and Sinclair Oil and Gas Company used it on the No. 1-A Montgomery located just a few miles away, also in Pecos County. This well, now the third deepest, drilled to a total depth of 23,400 ft. Another well in the area, Phillips' No. 1 Harral drilled below 20,000 ft using the two elevator, shock table pipe handling system. Some of the deep Oklahoma tests in progress are also using a similar system.

Deviated Hole

Crooked hole has been a situation

ONE OF THESE OTIS TUBING SAFETY VALVES SHUT IN THIS WELL
WHEN IT THREATENED TO BLOW WILD, AND SAVED US THOUSANDS OF DOLLARS
IN LOST PRODUCTION AND A POSSIBLE SERIOUS FIRE.
First in Pres
THE WELL WAS PRODUCING 2½ MMCFD OF GAS WITH 89 BD OF SAND-LADEN OIL WHEN A LEAK DEVELOPED AT THE FLANGE OF THE MASTER VALVE. AT THE TIME, THE FLOWING PRESSURE WAS 3,100 PSI, SO IT DIDN'T TAKE LONG FOR THE GAS AND SAND TO CUT OUT A SIZABLE HOLE. AS SOON AS THE PRESSURE DIFFERENTIAL EXCEEDED THE VALVE SETTING, THE OTIS VALVE AUTOMATICALLY SNAPPED SHUT.
THIS MORNING WE PUMPED DOWN THROUGH THE SAFETY VALVE AND KILLED THE WELL WITH WATER—THEN BROKE OUT THE MASTER VALVE TO REPAIR THE LEAKY CONNECTION. NOW WE'RE RESETTING THE TREE. WE CALLED OUT OTIS TO PULL, CHECK, AND REDRESS THE SAFETY VALVE BEFORE WE PUT THE WELL BACK ON PRODUCTION. THE VALVE'S PROBABLY O.K., BUT IT'S BEEN DOWN THERE 10 MONTHS AND UNDER OUR SAFETY PROGRAM WE PULL ALL OF OUR SAFETY VALVES PERIODICALLY FOR INSPECTION ANYWAY.

that Phillips has learned to live with. Maximum deviation of 9 degrees from vertical has been experienced.

Caliper surveys run often in the course of the drilling cycle nearly always showed the hole to be in good shape.

Mud System

The hydraulic system, which was an important factor in the excellent hole condition, weighed about 10.2 lb per gal with a funnel viscosity of 48 to 52 sec and a water loss of 5 cc per 30 sec. The low solids, water-base CMC emulsion mud system contained about 8 percent diesel oil, and also contained graphite to minimize torque and drag. This mud system was held constant nearly the full length of the hole.

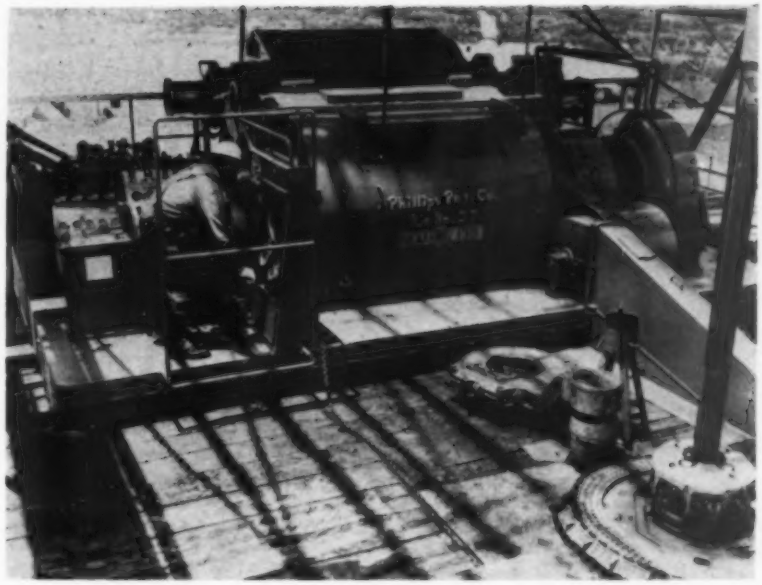
Open Hole

From surface to a depth of 1480 ft 20-in. OD casing was set; next was a 13⅜-in. string from surface to 6020 ft, followed by a 9⅝-in. casing string from the surface to 10,966 ft.

Below that depth to 22,919 ft was the longest section of open hole ever drilled through — nearly 12,000 ft.

Longest Casing String

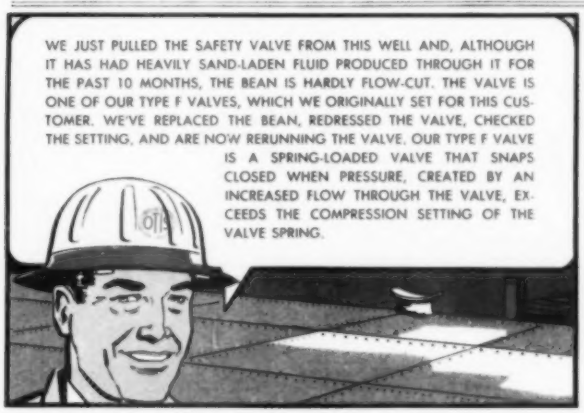
On June 11, 1958, some 572 joints of 7 and 7⅝-in. casing was run and cemented into the No. 1-EE. The casing, weighing nearly 700,000 lb, was set with 5183 cu ft of cement slurry.

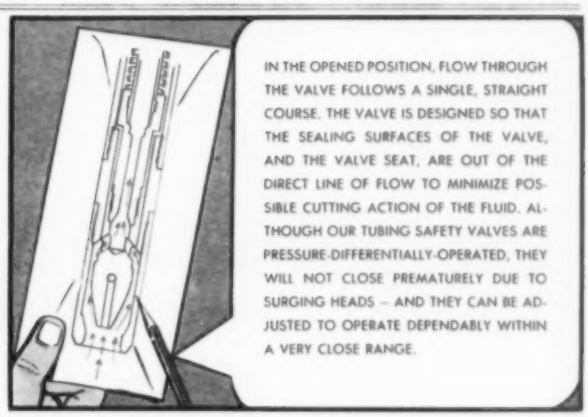


Ultimate in modern drilling controls were afforded drillers, like C. J. Land shown here, on Rig 27. Drawworks and mud pumps were powered by three 635-hp 12-cylinder V-block engines.

These two record-setting operations began early on June 10 and the last two joints were circulated to bottom at 2.15 p.m. the following day.

The record "intermediate" casing consisted of 12,642 ft (314 joints) of 7-in. OD high tensile P-110 casing below 10,277 ft (258 joints) of 7⅝-in. OD P-110 and S-95 casing. Bottom four joints of the string above the floating equipment were welded and then magnafluxed. Centralizers and scratchers were not used on the combination string. A crossover tool joined the 7


WE JUST PULLED THE SAFETY VALVE FROM THIS WELL AND, ALTHOUGH IT HAS HAD HEAVILY SAND-LADEN FLUID PRODUCED THROUGH IT FOR THE PAST 10 MONTHS, THE BEAN IS HARDLY FLOW-CUT. THE VALVE IS ONE OF OUR TYPE F VALVES, WHICH WE ORIGINALLY SET FOR THIS CUSTOMER. WE'VE REPLACED THE BEAN, REDRESSED THE VALVE, CHECKED THE SETTING, AND ARE NOW RERUNNING THE VALVE. OUR TYPE F VALVE IS A SPRING-LOADED VALVE THAT SNAPS CLOSED WHEN PRESSURE, CREATED BY AN INCREASED FLOW THROUGH THE VALVE, EXCEEDS THE COMPRESSION SETTING OF THE VALVE SPRING.
OTIS


IN THE OPENED POSITION, FLOW THROUGH THE VALVE FOLLOWS A SINGLE, STRAIGHT COURSE. THE VALVE IS DESIGNED SO THAT THE SEALING SURFACES OF THE VALVE, AND THE VALVE SEAT, ARE OUT OF THE DIRECT LINE OF FLOW TO MINIMIZE POSSIBLE CUTTING ACTION OF THE FLUID. ALTHOUGH OUR TUBING SAFETY VALVES ARE PRESSURE-DIFFERENTIALLY-OPERATED, THEY WILL NOT CLOSE PREMATURELY DUE TO SURGING HEADS – AND THEY CAN BE ADJUSTED TO OPERATE DEPENDABLY WITHIN A VERY CLOSE RANGE.

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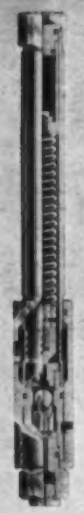

TYPE "L"
pressure operated

TYPE WF3
pilot operated

1959
TYPE WFBR
wire line
retrievable valve

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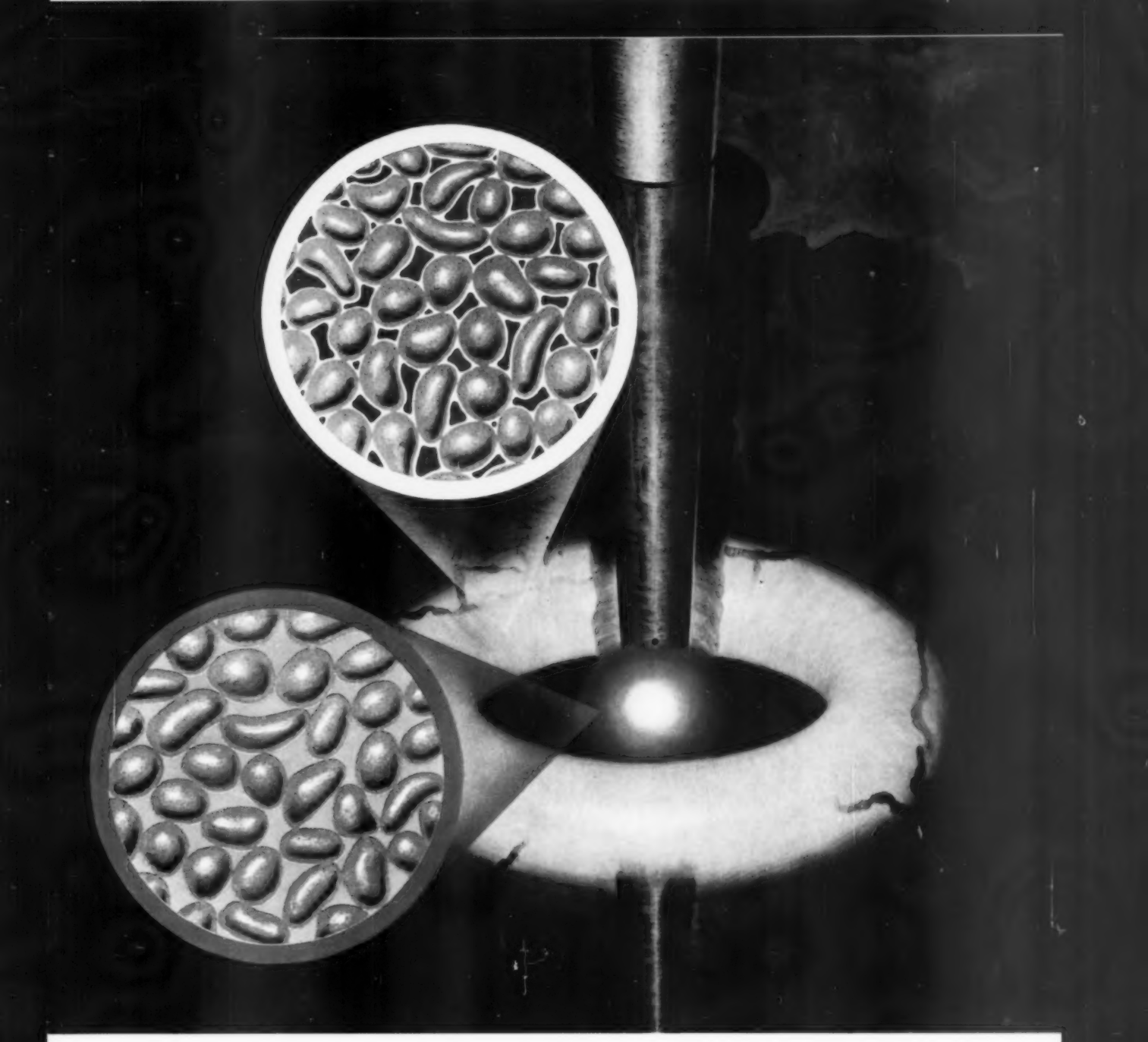

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Schlumberger—originator of logging and creator of its greatest advances—continues to lead the field with the Induction-Electrical Log.

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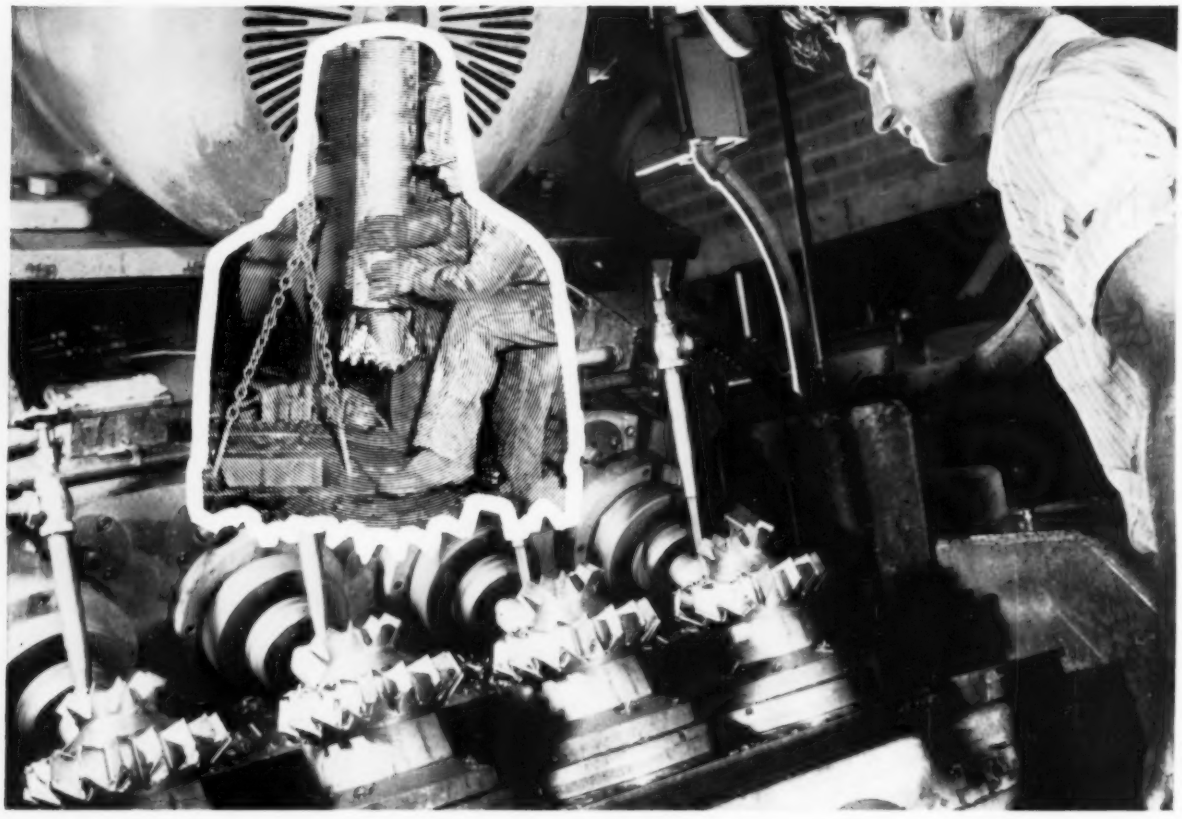

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and 7⅝-in. sections of casing.

Eighty-one percent automatic casing fillup, as well as mud circulation down the casing when desired, was provided by one fill shoe and three fill collars. The fill shoe, welded on bottom, measured 4½ ft long.

Big Cement Job

Four large trailer-mounted pumping units displaced a total of 5183 cu ft of cement slurry in this record single stage job. Slurry density was 10.8 lb per gal and tailed in with a 16.0 lb per gal mixture. The cement consisted of 1147 sacks of slow-setting cement, 42,127 lb (40 percent by weight) of diatomaceous earth and 1617 lb (1.5 percent by weight) of a low water-loss and retarder additive. The tail-in slurry for the lower portion of the casing and around the shoe consisted of 100 sacks of slow-setting, high temperature cement, and 141 lb (0.5 percent) of the low water loss and retarder additive. A total of 760 bbl of water was used in the mixing process.

Bottomhole temperature was 315 deg. Displacement rate for the cement job averaged 9.2 bbl per min. Total displacement was 951 bbl. Displacement pressure ranged from 900 psi to 1900 psi, but remained at about 1600 psi during most of the job. Three hours and 37 minutes were required for mixing, pumping and displacing.

This string of casing was set in 9-in. hole (by caliper survey) drilled with 8½-in. bits.

Below this string, Phillips drilled on to the TD of 25,340 ft.

After reaching total depth, a 2642 ft long, 5-in. OD liner was hung in the 7-in. casing to a depth of 25,328 ft. This liner was hung on October 24. It was run in on drillpipe, beginning at 1:30 a.m. and touched bottom at 4:30 that afternoon. It was necessary to wash the liner in, as a precautionary measure, for the last 200 ft. Then the well was circulated and the liner was hung 12 ft off bottom one hour later.

It took about 5 minutes to release the setting tool on a vertical setting casing hanger and make ready for cementing. The well was then circulated for two hours, and cement started in the hole at 10:30 p.m. with pressures up to 3500 psi. Bottomhole temperature was 357 deg.

Stretch and Torque

Setting the hanger brought to light the magnitude of this deep operation. The stretch in the drillpipe, on which the liner was lowered, was approximately 29 ft. There was approximately 14 rounds of torque between the surface and the bottom of the drill pipe. One service company engineer suggested that "It was very much like trying to maneuver a heavy weight on a long rubber band."

Record cementing, logging, and perforating jobs were established on the No. 1-EE location. The four cementing trucks in the picture put away 5183 cu ft of cement slurry in three hours and 37 min to set the 22,919 ft long "intermediate" casing string.

The liner string was composed of 5-in. 20.3 lb per ft P-110 pipe with 5-in. 18 lb flush joint threads. The liner hanger, specially made for the No. 1-EE, was 10 ft long. The setting tool was about the same length. Below the setting tool was a stinger of one joint of tubing. Made into the bottom of the tubing were two cups, tested to 8000 psi. The cups were positioned in the liner "looking down," to prevent the cement coming back up through the top of the liner. Below the cups was a hollow rubber liner scraper plug. This was screwed into a special choke nipple, hung on shear pins, with an "O"-ring for tightness.

After the liner was hung, the setting kelly was pulled up short distance, still leaving the cups in the liner. After the proper amount of cement was in the drillpipe, it was followed by a top plug of rubber with ball. This ball was used to successfully pick up the choke nipple below the cups, shear the pins and the two plugs were pumped as one

Special liner hanger suspended the last phase of the No. 1-EE casing program. Shown around the specially designed vertical-setting liner hanger are: Dean Falk, Phillips' drilling superintendent; Ed Keelan, Knowlton Oil Tool engineer; C. D. Johnson, Packers, Inc., and Norman Perkins, Phillips' area superintendent.

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strong fibers *permit mud circulation without loss.*

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By the time you get a good test on this pump, it will probably have paid for itself!

For one oil company (name upon request) a Double-Displacement Rod Pump paid out before the test was even completed!

If your wells are beginning to pump too much water and you must move more fluid to make your allowable, or if you would like to quit pumping so hard so you can slow down your pumping units (thereby saving wear and tear on your equipment) — ask your store, or one of our representatives, about a Double-Displacement Rod Pump.

The Double-Displacement is a traveling barrel, bottom hold-down assembly made up of two plungers and two barrel tubes which work simultaneously with a single set of valves. In operation, the assembly produces as two separate pumps made up in tandem which virtually doubles the volume of the unit — as compared to the displacement of comparable-sized pumps. The Double-Displacement also has the additional operating advantages of an insert-type pump which can be run and pulled on the rods. Hundreds of these pumps are in daily operation throughout the Mid-Continent and Gulf Coast areas, including many water flood projects.

H-F Double-Displacement Rod Pumps are available in a wide range of metal-to-metal, H-F "Flexite,"® or soft packing plungers with chrome-plated or heat-treated barrel tubes in 2"x1½", 2½"x2", and 3"x2½" sizes.

If you think a Double-Displacement Pump might solve the production problems you have been having with your wells — talk to your store, one of our many factory representatives throughout the oil patch, or write to us at P. O. Box 127 in Fort Worth. We'll be glad to send you complete details, illustrated literature, and comparison data without obligation.

NOTE — *This is the original Double-Displacement Pump — marketed by Harbison-Fischer in 1950 . . . not to be confused with imitation pumps which do not measure up to the performance record that hundreds of Double-Displacement Pumps have always enjoyed throughout the oil patch. When you run a Double-Displacement Pump, be sure you get the genuine original.*

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PAT.
ROD PUMPS

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piece to a shutoff at the bottom.

The liner was hung in 5¾-in. hole (below the 7-in. casing).

Record Logging

Prior to running the 5-in. liner, record logs were run to a depth of 25,182 ft, then the total depth. An electrical log, gamma ray-neutron log, microlog, and dipmeter survey were run to that depth. After logging operations the hole was drilled to total depth of 25,340 ft.

New Perforating Marks

The successful record-depth perforation was accomplished in the interval from 24,967 to 25,322 ft. Four shaped charge shots per foot, or a total of 1420, were used. Guns were fired rapidly so as to minimize the transmission of well temperature to the perforating equipment.

The previous logging record was achieved by the same service company in the same area in Phillips' No. 1-A Montgomery, logged to 23,000 ft and the previous perforating depth record was made in the same well in an interval of 230 ft extending to a depth of 22,880 ft.

Drillstem Testing

The Ellenburger was drillstem tested in the section of the deepest perforations, 24,967 to 25,322 ft, also setting a record.

Testing up the hole followed. The Montoya was tested, with no results, at 22,310 to 22,500 ft.

The No. 1-EE was then plugged back to 19,143 ft and tested in the second Devonian at 14,000-60 ft. Final tests were in the Wolfcamp through perforations at 8650-85 ft, getting a small gas flow and show of condensate with mud, after acidizing.

Geology

On the way down, in the early phases of drilling, Phillips had noted some shows of gas in the Leonard and Wolfcamp between 8118 and 11,715 ft, but a faulting condition was encountered in the deeper formations.

A total of 19 drillstem tests were taken in the well during the initial drilling phase to a depth of 17,331 ft.

Geology of the hole was uncertain all the way. Each new formation encountered was no less than a surprise. The well, located in the Sheffield Channel — a unique portion of the Permian Basin, was originally slated to go to the Ellenburger. The Ellenburger is the source of Texas' deepest production, at 15,000 ft, in the Puckett gas field 20 miles to the southeast of the No. 1-EE.

The Ellenburger was originally expected just below the Simpson. But because of an overthrust, the Ellen-

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burger were first encountered up the hole. Top of the Simpson was first found at 13,425 ft and the Ellenburger at 16,708 ft. The Simpson was again found at 20,520 ft. Soon after breaking the Texas depth record at 21,687 ft, a formation tentatively identified as Devonian was encountered.

Geologists now conclude that the first Devonian was topped at 13,185 ft; a second Devonian topped at 13,868 ft; third Devonian topped at 15,764 ft; the first Ellenburger encountered at 16,708 ft; entered the fourth Devonian at 21,740 ft; hit the fifth Devonian at 21,852 ft, and topped the second Ellenburger at 24,974 ft.

Shutdowns to Retool

The long period of fishing early in 1958, the time awaiting delivery of a specially-designed string of drillpipe, and time on bottom offered geologists time to study the maze of thrusted formations. Also, it allowed engineers time to study equipment design and safety factors. At no time during the 2-year, 4-month life of the No. 1-EE were these considerations put in second place in efforts to speed the operation.

Bits and Drillpipe

More than 300 bits of various sizes and types were run on Rig 27's tapered drilling string.

Down to a depth of 24,357 ft, a tapered drilling string was used, consisting of (from bottom to top): Seven 6½-in. drill collars, 327 joints of 4-in. Grade E, 14 lb per ft drill pipe; 110 joints of 4½-in. Grade E drill pipe, 16.6 lb per ft, and 280 joints of 4½-in. X-95, 16.6 lb per ft drillpipe.

At this depth, operations were suspended to order new and specially designed drillpipe. The final 983 ft of hole was drilled using 3½-in. drillpipe. The top 350 joints, approximately 10,500 ft, of drillpipe was 3½-in. 15.5 lb per ft P-105, Grade G, Range 2. Tool joints were ordered with boxes 1-in. longer than standard. Pipe was given hardness tests, magnetic particle and reflectoscope tests.

To run the 5-in., 20.41 lb per ft, Grade 4340 liner, Phillips picked up a tapered drilling tubing string consisting of 14,600 ft of 3½-in. pipe and 14,700 ft of 2⅞-in. chrome-moly tubing.

Rig 27

Equipment used to drill the world's deepest well was for the most part conventional and conservative. Drawworks was nominally rated by the manufacturer from 10,000 to 16,000 ft drilling. The drawworks has a 30 by 56¾-in. drum with 54-in. by 10⅜-in. water cooled brake rims. Auxiliary is a 60-in. single rotor hydraulic brake connected directly to the drawworks drum shaft.

Prime movers for both pumps and drawworks are three 635 hp 12-cylin-

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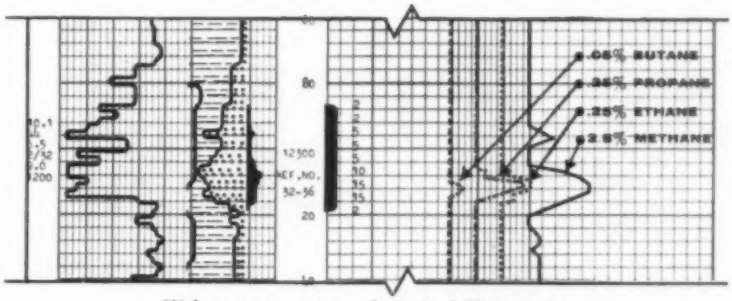

High propane content of gas in drilling mud is the distinguishing marker of oil producing zones.

A Mississippi wildcat recently completed in an unexplored area, had forty-five shows. One of them, identified as commercially productive by Hycalog gas CHRONOFRAC, has been confirmed by production tests at nearly 200 barrels per day.

The hole was completed with the barest minimum of coring and testing. Pipe was set to the sand indicated by Hycalog . . . *immediately zone tested* . . . and production commenced.

The gas CHRONOFRAC, developed by HYCALOG, has proven to be a valuable tool in the discovery of oil. The component analysis, not available in conventional well logging services, permits identification of areas where oil as well as gas may be produced.

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der V-block engines. These deliver a total maximum of 1915 hp.

Main mud pump, with 1000 input hp, is compounded to drawworks engines. The auxiliary, also tied into main compound, is a 7¾-in. by 18-in. pump with a maximum input horsepower of 600. Main pump has 8½-in. liner with a 16-in. stroke.

Derrick is standard-type, 136 ft high, has a 32 ft square base, and utilizes an 18 ft high substructure. Total load capacity is 1,000,000 lb.

Control equipment consists of two 10,000 psi test, annular type blowout preventers and a 10,000 psi test hydraulic double cellar control gate blowout preventer.

All traveling equipment is 500-ton test.

Steel mud pits were used and drilling water supplied from a well drilled close by. A complete mud logging unit is included in the long list of modern drilling equipment on the rig.

Operation Ceases

Rig 27 is now stacked on location of the No. 1-EE University, resting above many tons of casing, cement, mud, and several joints of lost drillpipe. The cost of the well is unofficially estimated to be more than $3,000,000.

What, other than a dry hole, did the money buy? It bought a rig capable of going to greater depths. It purchased a wealth of geological information about the peculiar Sheffield Channel. It produced new tools and practices now being used in many other deep wells. It reassured drillers and operators that suppliers and manufacturers could deliver equipment designed to operate under high temperature, great depths and extreme stress in a matter of weeks.

For example, one manufacturer made, tested and delivered 10,500 ft of drillpipe to Phillips' specifications in three weeks. One West Coast firm designed, made, tested, delivered and ran the liner hanger set near the well's bottom in six weeks. Loggers and perforators constructed special equipment with 29,000 ft of six-conductor, double steel armored cable, special control systems and prepared specially designed explosives, primacord and blasting caps for the deep well.

The No. 1-EE University is plugged and abandoned. Yes, it *was* a success without producing a drop of oil.

Acknowledgment

Material for this report came from several sources, but special acknowledgement goes to Halliburton Oil Well Cementing Company, Rector Well Equipment Company, Schlumberger Well Surveying Corporation, National Supply Company, Knowlton Oil Tool Company and Devex Engineering Company. ★ ★ ★

Books to Read . . .

Explorations East of the High Andes, *by Victor Oppenheim. Published by The Pageant Press, 101 Fifth Avenue, New York 3, New York. Pages, 267. Price, $5.*

Of definite value to the rising number of oilmen visiting and working in South America is this new volume by a petroleum consultant. Dr. Oppenheim's book reflects the history, people, governments and geology of Latin American countries as he viewed them during his travels while serving as state geologist, engineer or consultant to the governments of Argentina, Brazil, Colombia, Ecuador, and Peru, and visiting geologist to Bolivia, Uruguay and Venezuela.

The author's observations in biographical form will be interesting and informative to those who would familiarize themselves with this frontier and back country east of the High Andes.

Pumping Well Problem Analysis, *by J. M. Eubanks, B. L. Franks, D. K. Lawrence, T. E. Maxwell, and C. J. Merryman. Published by Joe Chastain, Box 4002, Midland, Texas. Pages, 202. Price, $4.*

Average volumetric efficiency of a bottom-hole pump is probably less than 40 percent, say the authors of this manual, all members of Sun Oil Company's engineering department. With proper understanding of pumping well problem, this could easily be raised to 60 to 75 percent, and with a little effort in recognizing true physical laws and putting them into practice, the 80-80 percent efficiency should be obtained, the book suggests. Well weighing, through the medium of the dynamometer, offers a means of analyzing these pumping well problems where sucker rods are incorporated.

Tests and applications of the dynamometer and auxiliary equipment are outlined, and other routine field tests that can be made without the use of special equipment are discussed.

1958 Structure Maps of Texas Oil Fields, *published by Rinehart Oil News Company, 2300 Reagan, Dallas, Texas. Pages, 190. Price, $17.50.*

The fifth annual edition of the book contains all map exhibits, which were suitable for reproduction, as submitted during the past year to the Texas Railroad Commission by operators for rulings on field discoveries, injection projects, and Rule 37 permits. Material is arranged by counties and by districts, and is bound into a single indexed volume. Each full-page map is identified according to county, district, producing formation, contoured interval, and type hearing.

Henry B. Woods, newly appointed director of research, Hughes Tool Company, is shown here with two models of the "chert" bit he helped to design. Instead of conventional teeth these bits have sintered tungsten carbide inserts pressed into the cone shells. The bit on the right is the first "chert" bit ever run in the field — November 7, 1950. Woods personally supervised the test. The jet bit on the left is a recent model pulled after making a record-breaking run. Its condition is such that it could be rerun in the hole.

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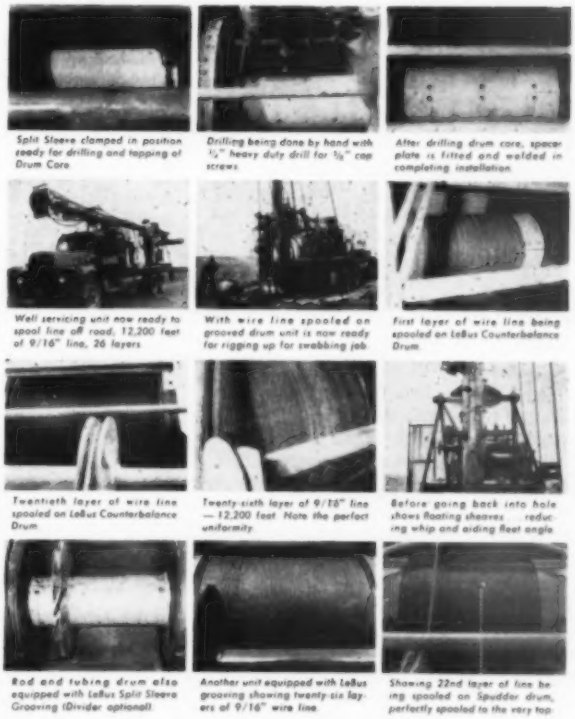

Split Sleeve clamped in position ready for drilling and tapping of Drum Core.

Drilling being done by hand with ½" heavy duty drill for ⅝" cap screws.

After drilling drum core, spacer plate is fitted and welded in completing installation.

Well servicing unit now ready to spool line off road, 12,200 feet of 9/16" line, 26 layers.

With wire line spooled on grooved drum unit is now ready for rigging up for swabbing job.

First layer of wire line being spooled on LeBus Counterbalance Drum.

Twentieth layer of wire line spooled on LeBus Counterbalance Drum.

Twenty-sixth layer of 9/16" line — 12,200 feet. Note the perfect uniformity.

Before going back into hole shows floating sheaves — reducing whip and aiding float angle.

Rod and tubing drum also equipped with LeBus Split Sleeve Grooving (Divider optional).

Another unit equipped with LeBus grooving showing twenty-six layers of 9/16" wire line.

Showing 22nd layer of line being spooled on Spuddar drum, perfectly spooled to the very top.

Lebus can engineer your spooling to save you hoisting time and line with added safety

With Lebus Counterbalance Spooling you can avoid waits caused by improper spooling, cutting in, tangled line and excessive wear. Furthermore, Lebus can give you service anywhere and utilize your present drums.

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What's doing in DRILLING

Drilling Costs Drop in U. S.

Average total cost of drilling domestic oil and gas wells declined to $13.25 per ft in 1958 from an all-time high of $13.60 in 1957, and total domestic footage dropped to 194,756,301 from 219,403,102. The figures were estimated in an annual survey made by the American Association of Oilwell Drilling Contractors.

Brad Mills, retiring executive vice president of the association, attributed the cost reduction to "such factors as a smaller percentage of wildcat wells, slight modifications in some casing programs, a lesser average well depth, and an improved rate of penetration." He predicted that, with petroleum demand forecasts coupled with "the extreme need for developing adequate domestic reserves," drilling activity will not fall beneath that of last year in the immediate future.

High Cost of Drilling in Alaska

The cost of exploration and drilling is presently about two to three times that in the United States, and this same ratio will probably hold true for the cost of production and transportation. So stated J. Ben Carsey, exploration advisor for Humble Oil & Refining Company in an address to the Houston Geological Society. However, he said that Alaska's oil and gas potential is evident because of its several important sedimentary basins.

John R. Woolson of United Geophysical Corporation, Houston, said at the meeting that the geology of the northern one-third of Alaska resembles that of the Denver-Julesburg and Alberta basins, and predicted that the Lisburne limestone of the Mississippian will be a principal target of wildcatters.

Offshore Drilling Company Formed

Formation of the Global Marine Exploration Company, an offshore drilling, engineering, and construction company, has been announced. The new company is designed to offer the offshore equipment, engineering, and experience of the late CUSS Group (Continental, Union, Shell, and Superior Oil companies). Personnel of the company will include personnel lately associated with the CUSS Group and will include as officers: R. F. Bauer, president; A. J. Field, vice president and general manager; Hal Stratton, vice president; and other key personnel. Company offices are at 650 South Grand Avenue, Los Angeles 17, California.

Canada's Deepest Well Abandoned as Duster

The deepest well in Canada has been abandoned more than 1000 ft short of its goal. The Texaco-NFA Simonette in the Rocky Mountain foothill area went down to 15,293 ft. Original plans called for the hole to be drilled to 16,500 ft, but costly fishing operations caused operators to abandon the venture.

Rig Drilling After Record Move

The fastest movement of rig and equipment from California to Alaska was completed January 31 when the Halbouty Alaska Oil Company-King Oil Inc. No. 1 well was spudded. The well was spudded in the Swanson River area of the Kenai Peninsula and 60 ft of conductor pipe was cemented in the hole with a total time of 20 days elapsing from loading the rig aboard the ship to spudding.

The rig is completely winterized for the 10-below-zero weather on the peninsula. A steam boiler furnishes heat for the derrick floor and the steel mud pits. Steam pipes were run down inside the conductor pipe to prevent the cement from freezing before it set around the pipe.

Drilling Firm Formed in Arkansas

Rox Drilling Company has been formed at Fort Smith, Arkansas, following the purchase of four strings of cable tools from the Levieux Drilling Company of Ozark, Arkansas, and two strings of cable tools from the Athletic Mining & Smelting Company of Fort Smith. All of the rigs are now running in the Arkansas Valley gas district.

Officers of the company are: Raymond F. Orr, president; Harvie L. Horton, vice president and drilling superintendent; Spence A. Leamons, secretary; and Ander K. Orr, treasurer, all of Fort Smith. James F. Orr, of Poteau, Oklahoma, is a director.

Tidewater Sets Record Well Drilling Time

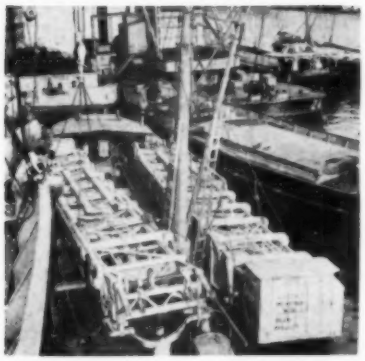
The fastest known record for shallow well drilling time has been set by Tidewater Oil Company with the completion of its Junction 29 well in the Kern River field, at a depth of 906 ft, in 26 hours from spudding to landing the liner. Significant factor in the setting of the new record was the use of a flash setting cement additive which remains fluid for 30 minutes below 140 degrees, but takes a hard set in 2 hours.

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oilwell Drilling Contractors by Hughes Tool Company.

	Jan. 19	Jan. 26	Feb. 2	Feb. 9
Alabama	9	8	8	8
Arkansas	11	7	16	13
Arizona	0	0	0	0
California	73	74	72	67
California—Offshore	5	5	4	3
Total California	78	79	76	70
Colorado	23	23	22	26
Florida	1	1	1	1
Idaho	0	0	0	0
Illinois	44	39	20	24
Indiana	6	4	4	4
Iowa	3	3	3	3
Kansas	118	109	118	131
Kentucky	7	5	5	5
North Louisiana	44	36	36	31
South Louisiana — Inland Waters	127	130	132	128
South Louisiana Land	113	97	101	101
South Louisiana — Offshore	33	34	36	37
Total Louisiana	317	297	305	297
Maryland	2	2	2	1
Michigan	10	11	11	17
Missouri	0	0	55	52
Montana	17	18	0	0
Mississippi	56	62	16	16
Nebraska	22	25	25	21
Nevada	0	0	0	0
New Mexico	94	100	101	97
New York	0	0	0	0
North Dakota	30	29	29	28
Ohio	3	4	2	2
Oklahoma	194	176	177	202
Oregon	0	0	0	0
Pennsylvania	11	9	11	11
South Dakota	0	0	1	1
So. Tex. & Gulf C.— Inland	3	7	7	8
So. Tex. & Gulf C.— Land	124	139	146	129
So. Tex. & Gulf C.— Offshore	2	1	1	2
North and East Texas	149	157	154	162
West Central Texas	265	251	251	250
West Texas	135	149	133	134
Total Texas	678	694	692	685
Utah	30	28	28	28
Washington	1	1	1	1
West Virginia	3	2	2	2
Wyoming	54	57	50	49
Total U. S.	1822	1793	1781	1795
Western Canada	203	217	215	222
Eastern Canada	0	0	0	0
Grand Total	2025	2010	1996	2017

First of Thirty Rigs Arrive in Buenos Aires



The first of a shipment of American-designed rigs have arrived in Buenos Aires from Nuovo-Pignone in Florence, Italy. These rigs, construction of which was licensed to the Italian firm by European subsidiaries of Dresser Industries, Inc., are of Ideco design and are part of a purchase by Y. P. F. of 30 identical drilling rigs. The first 10 were manufactured in Ideco's Beaumont plant and the remaining 20 are being supplied by Nuovo-Pignone.

Turbodrill Sets Record In East Texas Test

A record turbodrill run for diamond bits was made when the French Neyrpic turbodrill was recently tested in a Shell Oil Company well in Wood County, Texas. Performance of the turbodrill was termed the most impressive results to date.

Two records were set during the test: The most footage — 436 ft — was made in a single run using diamond bits; the longest single turbine run — 61½ hr. A Shell production department spokesman said that it would be possible in the future to turbodrill the Rodessa Lime of the Lower Glen Rose formation at a savings of approximately 30 percent.

The test was part of a series of 24 being conducted by Shell in the United States and Canada under a 2-year co-operation program with Dresser Industries.

Canadian Firm Sells Drilling Rigs

Bailey Selburn Oil & Gas Ltd., has announced the sale of all drilling assets owned by its subsidiary, Trident Drilling Company, Ltd., to Peter Bawden Drilling Company of Calgary, Alberta. The move was based on expectations of more efficient operations as a result of separating their basic operations from contract drilling activities, following such a trend now in motion among exploration companies both in Canada and the United States.

Gusher Too Good To Be True

Momentary contender for the world's shallowest well recently flowed 4000 bbl per hr from 2½ ft! But the fabulous strike was soon abandoned when it was discovered that the gushing crude oil was coming from a 16-in. pipeline owned by Service Pipe Line Company.

A contract rig, on location nine miles east of Bretch, Oklahoma, struck oil just a few minutes after spudding in when the bit pierced the pipeline carrying oil from West Texas fields to Drumright.

New Water Shutoff Process Introduced

A new water shutoff process developed by Gulf Oil Company promises to extend the boundaries of air and gas drilling. The method has proved to be 99 to 100 percent effective in field trials for shutting off water flows varying in size from 2 to 2200 gal per hr.

Water shutoff is achieved by injecting a special gas into the porous sand which is producing the water. The gas and water react to create a solid, water-insoluble precipitate which plugs the openings between sand grains for about a foot around the well bore.

AAODC Rotary Drilling and Education and Training Committees Meet in Dallas

Field operations and training programs were the order of business when subcommittees of the AAODC Drilling and Education and Training Committees met in Dallas on January 23 and 24. Reports were made to the two standing committees which then met in joint session.

Joint session of AAODC Rotary Drilling Committee and Education and Training Committee brings together (at head table, left to right) Brad Mills, retiring AAODC executive vice president; H. W. Davidson, vice chairman of Education and Training Committee; M. M. Brantly, chairman of Air/Gas Drilling Committee; Joe Zeppa, AAODC president; B. E. Groenewold, chairman of Rotary Drilling Committee; Frank Whitley, chairman of Education and Training Committee; H. J. Magner, vice chairman of Rotary Drilling Committee; and Jack J. Harrigan, vice chairman of Education and Training Committee.

Meeting of the AAODC Education and Training Committee; Frank Whitley (seated, center), chairman.

Meeting of AAODC Rotary Drilling Committee, B. E. Groenewold (standing, right), committee chairman.

EXPLORATION ACTIVITIES

OHIO

New Production Depth Record Being Set at Gas Find

Ohio Fuel Gas Company, East Ohio Gas Company and Wiser Oil Company are completing the No. 1-A S. L. Smith Estate well in the Hinckley township, Medina County, at a depth of 5927 ft. The well, a geological wildcat bottomed at 7040 ft, has tested commercial quantities of gas in the Trenton formation just above the plug-back depth of 5927 ft.

Completion of the well at this depth would set a new production depth record for the state; lowest production in the area has been in the Clinton sand at 2500-3000 ft. This formation has been producing gas in this portion of northern Ohio for almost a century.

The No. 1-A Smith is one of the deepest tests ever drilled in the state. Deepest on record is Benedum-Trees' No. 1 Knowlton in Washington County, drilled in 1933 to a total depth of 7889 ft.

TEXAS

Fina, Bolin Open New Tannehill Pay in Knox

American Petrofina Company of Texas and Bolin Oil Company No. 1 Davis, Knox County, wildcat well ran drillstem test between 2326-32 ft in Tannehill formation oil sand. Recovery in one hour was 930 ft of oil, 60 ft of heavy oil and gas cut mud and 60 ft of brackish water. Bottom-hole flowing pressure was 275 psi and bottom-hole shut in pressure was 1000 psi. Well is on a block of 798 acres owned three-fourths by American Petrofina and one-fourth by Bolin. Supporting the tests are Skelly Oil Company, Pan American Petroleum Corporation, and Katz Oil Company.

Rank Brooks County 'Cat Completed in Frio

The Texas Company announced the completion of its McGill Bros. NCT-1, Well No. 19, in southwestern Brooks County, Texas, as a discovery well.

Drilled as a rank wildcat the well was completed in a Frio sand at 8020-52 ft. On potential test the well flowed 184 bbl of 39.2 deg pipeline oil per day on a X-32 choke through perforations from 8030 to 8035 ft. Tubing pressure was 1100 psi and the gas-oil ratio 703 to 1.

Earlier Texaco reported a rich gas condensate test from a lower sand at 8830 to 8850 ft.

Location is four miles east of Kelsey Deep field in Brooks County.

Wolfcamp Reef Productive In Gaines County Prospector

Tennessee Gas and Oil Company, a division of Tennessee Gas Transmission Company, has brought in a wildcat oil well of indicated major significance in east central Gaines County, Texas.

The well, the Kay Kimball No.1-A, flowed 44 bbl of oil per hour on a one hour and 26-minute drillstem test, at 10,350-435 ft from a biohermal reef in the Wolfcamp. Electric logs indicate about 55 ft of net pay in that interval.

Located about 13 miles east of Seminole, Texas, in the West McKenzie Lake area, the well is about five miles south of the Felmac field, which produces from the Mississippian. The nearest production from the Wolfcamp is in the Adair field, about 20 miles to the northwest in Terry County.

The well is now drilling ahead, with a projected depth of 11,500 ft to test the Strawn limestone of the Pennsylvanian. Most of the reef production in West Texas is from the Pennsylvanian.

First Gulf Coast Try Yields Yegua Discovery

The Minerals Division of Gulf States Land & Industries, Inc., with its first venture in the Gulf Coast area, the H. D. Carpenter et al No. 1 well, made a significant oil discovery opening a new Yegua fault segment on the Northeast flank of Sour Lake Dome, Hardin County.

The Carpenter well was perforated from 9189 to 9197 ft after topping producing sand section at 9159 ft. The well is on a potential flow of 33 deg oil at a daily rate of 203.58 bbl on ⅛-in. choke with flowing tubing pressure of 1840 psi and gas-oil ratio of 997 to 1.

ARGENTINA

Union Oil Begins Seismic Work, Prepares for Spring Drilling

Union Oil Company reflection seismograph crews will begin operations in Argentina this week to supplement airborne magnetometer crews in evaluating 4,000,000 acres of government land the company has under contract preparatory to exploratory drilling this spring.

Union's Argentina operations are near the southerly tip of South America where the company has a 27-year contract for exclusive exploration and development to two parcels totalling 4,000,000 acres in the provinces of Chabut and Santa Cruz. Operations are being directed from Union's headquarters in Buenos Aires.

UNITED KINGDOM

BP Makes Oil Discovery Near Corringham, England

Oil has been discovered by BP Exploration Company 1½ miles east of Gainsborough in Lincolnshire, England. A test well drilled by BP struck oil at a depth of some 4600 ft and during tests the well has produced at a rate of 110 bbl per day.

This new find is about 2½ miles west of Corringham where the company found oil in July 1958. BP Exploration Company is now preparing to delimit the Corringham field and also the field at Bothamsall, Nottinghamshire, which it discovered earlier last year.

Over the past 12 months, the company has continued its search for oil in the United Kingdom, mainly in areas around the existing East Midland oil fields and in Southern England. It has also been searching for natural gas on behalf of the Gas Council.

LOUISIANA

Four Pays Productive At Jeanerette Dome Stepout

The Atlantic Refining Company has logged 236 ft of net gas distillate sand in four separate pays in its Adeline Sugar Factory No. D-1A well located in St. Mary Parish.

This well was originally drilled to 9500 ft and abandoned as a dry hole in 1954. The well was recently reentered and is currently drilling at 12,600 ft. The well is a 1550 ft stepout from present production on the northeast flank of the Jeanerette Dome. Atlantic has considerable acreage near this well.

Logging... Down Under

Alaska, Central and South America, . . . now *Australia* — another pin in Core Lab's map of overseas well logging and core analysis operations.

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Specifically — these field laboratories feature a highly-efficient mud-pump / gas-trap / shale-shaker system, instrumentation for comprehensive recordings of related rig activity, and conventional core analysis equipment. Add either a Mass Spectrometer or an Infra-Red & Chromatograph system and the complete service becomes a veritable "super-tool" for exploratory work.

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

TURKEY

Pan American Land & Oil Take New Concessions

Pan American Land & Oil Royalty Company has obtained and is in the process of exploring 187,740 acres in District V and 481,372 acres in District VI, both in southeastern Turkey, and 244,131 acres in District II, in western Turkey.

DeGolyer and MacNaughton Inc. currently is making a detailed geological study of the concession blocks for Pan Land.

The two concessions held by Pan Land Oil in District V and the four in District VI are located within proved oil provinces, and either cover well defined anticlinal structures or are located on the extension of important anticlinal trends under concessions to others, company officials say.

District V is in the Middle East Structural Trend Zone and includes the Garzan and Raman fields, principal producing oil fields of Turkey.

The Kahta field is 55 miles east of Pan Land's VI/A block. The Kahta field major discovery this year by California Asiatic Oil Company (Caltex) further suggests an extension of the Middle East Trend into Turkey.

Weather Forces Drilling Shutdown

Adverse weather conditions have suspended operations at Bolsa Chica Oil Corporation's exploratory well in southeastern Turkey. This well, Bolsa Chica "Hazro" No. 1, was spudded on October 15 and had reached a depth of 4050 ft when weather indicated a shutdown.

Ordinarily, normal weather conditions in Turkey should permit resumption of drilling operations in late March or early April. In the interval an intensive refinement and review of geological information is being conducted by the company's geologists in Turkey.

Originally scheduled for a depth of 6000 ft, Hazro No. 1 is the second in a series of wells planned by the company and its associates to test a block of 370,000 acres held in this area. The first test, Zengilan No. 1, on a separate structure 17 miles to the west, was abandoned last September at a total depth of 6449 ft.

CALIFORNIA

New Deep Zone Flows Oil in Bridge Field

Discovery of a new deep zone in the Bridge field near Santa Paula, with a well flowing at the rate of 800 bbl a day of 34.9 deg crude oil was announced by Union Oil Company of California.

Drilled as a development well, Hill No. 1, in the extreme westerly part of the field, went to a total depth of 11,193 ft and is being completed in two separate zones.

The bottom zone, perforated from 9654 to 10,780 ft, flowed initially at the rate of 800 bbl a day. This is a new deep zone for the area. The upper zone, which is the regular producing zone, has been perforated from 8780 to 9450 ft, and is being placed on production.

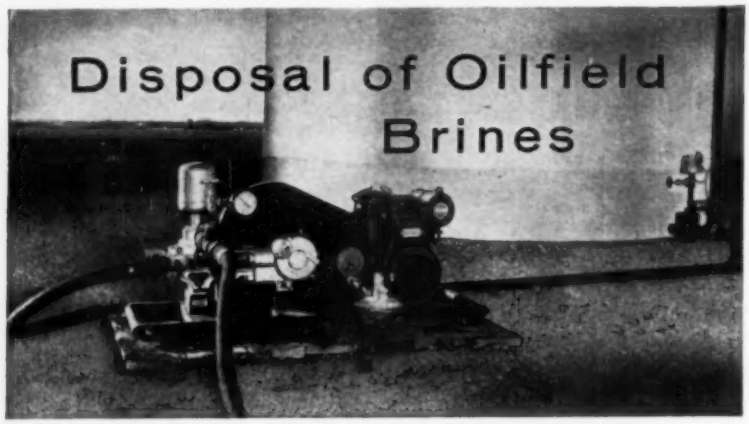
IRAN

Fire-Branded Well Sets Depth Record

The Iranian Oil Exploration & Producing Company's exploratory well Ahwaz No. 6 has now reached a depth of 12,742 ft and is the deepest well ever drilled in southern Iran. Drilling is continuing.

Ahwaz No. 6 is the same well which in April 1958 was the scene of a spectacular fire when gas erupted from a depth of 8093 ft, resulting in a 47-day long struggle to bring the well under control.

After the site of the well had been cleared and a new derrick rigged up it was possible to carry the well on down to its present record depth.



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This equipment meets a growing need for an economical and practical means to prevent salt-water pollution of streams and surface pollution of land acreage. This is insurance against possible expensive litigation and government citations. Many of these installations are now in use, operating around the clock.

This is a typical oil field assignment for Wisconsin Heavy-Duty Air-Cooled Engines . . . designed and built to "take it" under continuous loads, day after day, month after month . . . in any location, any climate. Rugged, high-quality construction in all details, combined with load-lugging, high torque performance, and self-sustaining operating dependability, are features that keep the equipment going and hold down maintenance costs.

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ALASKA

Companies Begin Survey Of Cook Inlet Waters

A joint over-water seismic study of Cook Inlet is underway by Standard Oil Company of California, Western Operations, Inc., as operator, and several other companies.

Participating in the offshore survey are Ohio Oil, Pan American, Richfield, Shell, Sunray, Superior, Texas, Union and Western Gulf. Work began the first of the year.

Waters to be surveyed are adjacent to the Kenai Peninsula lowlands, site of the Standard-Richfield Swanson River Unit, where an oil discovery made in 1957 is currently undergoing testing.

The $1,000,000 seismic program will cover a broad area to give participating companies sufficient preliminary data on which to make individual appraisals of the potential of the submerged lands. Results are intended to serve as a guide for determining what follow up work, if any, each of the companies will undertake.

NORTH DAKOTA

Lion, Pan Am Get 506 BPD Nesson Oiler

The completion of the Bly No. 1 in Burke County, as a semi-wildcat well has been announced by the Lion Oil Division of Monsanto Chemical Company.

The well flowed at the rate of 506 bbl per day of 39.2 deg oil through a 20/64-in. choke with 950 psi tubing pressure. Completion is through perforations from 6110 to 6130 ft in the Nesson formation. There was a small oil show in the Midale sand.

The new well is about two miles south of Lignite, North Dakota, and 1½ miles from the nearest production in the South Rival field and 1¼ miles from the nearest production in the Lignite field.

Monsanto and the Pan-American Petroleum Corporation each have a 50 percent interest in the well.

BOLIVIA

Atlantic Takes Option Covering 1,250,000 Acres

Drilling & Exploration Company, Inc., Dallas, Texas, and The Atlantic Refining Company have consummated an agreement by which Atlantic has acquired a one year option for an 80 percent interest in concessions covering approximately 1,250,000 acres in Zone No. 1 of the Petroleum Reserve Area of the Republic of Boliva. The acreage involved is presently held by a Drilexco wholly-owned subsidiary, Bolivia Petroleum Corporation.

Another plus value:

INHERENT LUBRICATING QUALITIES BROADEN USE OF SEECO-MUL AS E-P ADDITIVE

On your next well, try Seeco-Mul Drilling Mud Emulsifier as an extreme pressure additive. Many operators have recently discovered this extra advantage in Seeco-Mul; in fact we can show you data on a number of field wells drilled under almost identical conditions that will convince you that Seeco-Mul is the most effective E-P agent you can use.

The efficiency of Seeco-Mul as an E-P agent is due to its chemical structure—the ability of one end of the Seeco-Mul molecule to adhere tightly to a metal surface, attracting another molecule to form the familiar micelle, or the joining of two molecules at opposite ends. This layer attracts other Seeco-Mul molecules, which build up to an extremely tough lubricating film that is difficult to remove and will withstand high pressure, successfully reducing metal-to-metal contact and subsequent wear, or galling, of the bearing surfaces.[1]

In addition to the E-P qualities, you get many other advantages with Seeco-Mul. Inasmuch as Seeco-Mul is a chemical emulsifier with superior wetting abilities, it is often run in so-called "soap" drilling fluids (the addition of detergents to fresh water muds, oil-and-water, and water-clay systems) to lower the surface tension, thereby wetting the formation ahead of the bit and keeping the bit clean. Such systems also afford a faster penetration rate and aid the suspended solids to drop out in the pits.

Too, with good lubricating qualities in the mud, less drill stem torque is required, pump pressures can be lowered and more evenly sustained, and a higher velocity of the fluid on bottom can be obtained . . . all of which means longer service life for liners, collars, tool joints, drill pipe, and the bits themselves.

Add to this the longer bit runs and the consequent savings in bits and rig time and you will agree that adding Seeco-Mul to the system is an investment rather than a drilling expense.

Let us show you how you can use Seeco-Mul profitably. We'll gladly send you illustrated literature and a lab sample of Seeco-Mul, or contact your local mud dealer. You can get full particulars without obligation.

[1] *McCutcheon, John W., "Synthetic Detergents."*

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CROSSETT **Seeco-Mul** **DRILLING MUD EMULSIFIER**

Manufactured by the Chemical Division of The Crossett Company, Crossett, Arkansas

Seeco-Mul is the dried flake form of a compound of the sodium salts of abietic, linoleic, and oleic acids, together with quantities of wood tannins and lignins.

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A completely guarded squirrel-cage induction motor with exclusive design for oil field service. Heavy-duty protected frame prevents entry of dripping liquids, flying chips or falling particles. Available with high torque, normal starting current—high slip, high starting torque—or general purpose normal torque. Ratings from ½ to 40 hp., 3600 to 600 rpm.

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RUNNING TOUR with

▸ **W. F. Knode,** petroleum consultant, will move to new offices in the Toronto General Trusts Building, Calgary, Alberta, Canada.

▸ **Loring B. Snedden** has been named geologist for **Signal Oil and Gas Company.** Snedden has been with Hancock Oil Company since 1954, when he joined them as chief geologist.

▸ **Victor H. King,** has been elected director of exploration, General Petroleum Corporation, succeeding **Carroll M. Wagner,** who retired after 40 years of service. King was formerly manager of exploration.

V. H. King

C. M. Wagner

▸ **William K. Horn** has joined the staff of H. J. Gruy and Associates as a methods analyst. Prior to joining Gruy, Horn was supervisor of accounts payable for Slick Airways, Inc.

▸ **George C. Hardin Jr.,** exploration and production manager for the Michel T. Halbouty Oil and Gas Interests, and executive vice president of the Halbouty Alaska Oil Company, has been elected president of the Gulf Coast Association of Geological Societies. Other newly elected officers are **Lyle H. Harvey** of New Orleans (John W. Mecom), vice president; **Weldon C. Henkhaus** of San Antonio (Arkansas Fuel Oil Corp.), secretary; and **James A. Wheeler,** consulting geologist of Houston, treasurer.

▸ **Karl E. Gorham,** has been promoted to superintendent of the southern production division of the Ohio Fuel Gas Company. Gorham was formerly district foreman at Ohio Fuel's southern production division.

▸ **George E. Cameron** has been appointed vice-president in charge of finance for Brown Drilling and affiliated companies.

He was formerly chief accountant for the Long Beach Oil Development Company.

▸ **Jack R. Fraser** was elected vice president in charge of the newly formed gas department at Republic Natural Gas Company. He previously held the position of senior staff engineer.

▸ **Joseph P. D. Hull Jr.** has joined Kerr-McGee Oil Industries, Inc., as staff exploration geologist in the Oklahoma City office. He formerly was associated with Humble Oil and Refining Company.

▸ **Howard Ritzma** has joined the geological consulting firm, Dan Turner and Associates, Denver, Colorado. He was formerly geologist and partner in Compass Exploration.

MEN in the INDUSTRY

Elard L. Haden, has been promoted to research engineer in Continental Oil Company's production research division. Haden received his bachelor's degree in chemistry from Hendrix College and his master's degree in chemistry from Louisiana State University.

Hal H. Bybee has been promoted to regional geologist for Continental Oil's CATC marine region. He was formerly senior geologist in the CATC marine region and succeeds **R. M. Dungan,** who recently transferred to Conoco's western region offices.

John W. McReynolds, Houston, assistant regional land superintendent, has been promoted to division land superintendent at Corpus Christi, Texas, succeeding the late T. D. Craft. **James A. Wilkerson,** Houston, division land superintendent, has replaced McReynolds and **H. L. Dubuisson,** New Orleans, Louisiana, assistant division land superintendent, replaces Wilkerson.

Martin G. Browne has been promoted from district sales engineer to district manager of Diamond Oil Well Drilling Company. He will direct activities for the Midland district.

Charles M. Wanner, consulting geologist, is joining Drilling and Exploration Company, Inc., as assistant to **George H. Thomas,** manager of the company's Eastern Hemisphere operations and will be located in The Hague.

R. O. Garrett

Robert O. Garrett has been elected president of Texas Gas Exploration Corporation. Garrett formerly was vice president and general manager of the corporation, and as president will continue also as general manager and a member of the board of directors.

J. M. Roberts, area land agent for Shell Oil Company in Houston, has been appointed area representative for Shell Canadian Exploration Company. He will continue his present duties as land agent and will remain in Houston. He succeeds **F. J. Margeson,** who recently retired.

P. D. Caldwell, head office jobber-distributor representative in Shell Oil's marketing department, is retiring after 34 years' service with the firm.

S. W. Totten has been appointed director, vice president and general manager of exploration for Standard Oil Company of California, Western Operations, Inc. He succeeds **O. F. Van Beveren** who has been named vice president of American Overseas Petroleum Limited. Totten was formerly vice president of The California Company, and has been succeeded by **H. C. Bemis,** former superintendent of western operations' Southern California exploration district.

Eugene A. Durden has been named resident auditor of Sun Oil Company's Latin America production division. Durden was formerly in the auditing section at Dallas, Texas.

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New York City will be host to this great international event which will be attended by thousands of the world's leading oil men from over 45 countries.

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At the 5th World Petroleum Congress Exposition, there will be more than 275 fact-filled exhibits demonstrating the newest equipment, techniques, services and materials that have been recently developed for use in the petroleum and petrochemical industries.

It's your special opportunity to see, discuss and compare these latest developments for use in oil research, production, refining, transportation . . . plus nuclear energy applications.

Plan now to attend . . . and bring your key men with you. Their visit will stimulate fresh thinking and new approaches to many problems—just one idea picked up here will make their trip more than worthwhile.

For advance registration and hotel information write the Exposition at 480 Lexington Avenue, New York 17, N. Y. 1240

5th

WORLD PETROLEUM CONGRESS EXPOSITION

New York Coliseum

June 1-5, 1959

Management: International Exposition Co.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

RUNNING TOUR

▸ **H. D. Becwar,** division geologist of Houston division of The Texas Company's domestic producing department, has been promoted to assistant division manager of the Denver division.

R. E. Hackbarth, who started with Texaco in south Texas in 1941, has replaced Becwar in Houston.

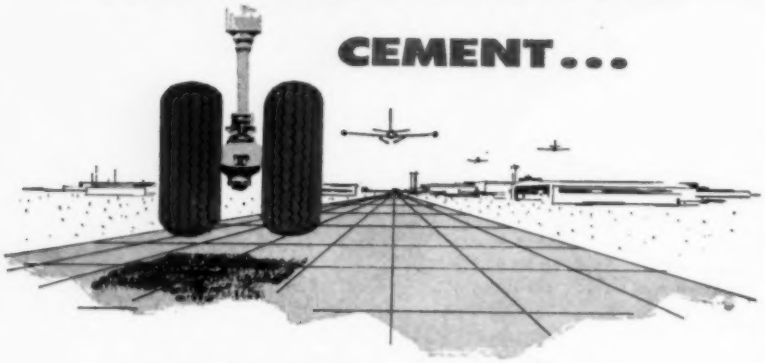
▸ **Lloyd D. Traupe,** formerly assistant division geologist of the Ohio Oil Company's Houston (Tex.) production division, recently was transferred to the general office at Findlay, Ohio to serve on the staff of the chief geologist.

▸ **Fred C. Beleau,** a veteran of more than 41 years' experience in oil producing operations in the U.S. and Canada, has retired from Pan American Petroleum Corporation. **C. L. Kelley** will succeed Beleau as district superintendent in Midland. Kelley had been district superintendent in Roswell, New Mexico.

Ralph L. Hendrickson has retired from Pan Am after 40 years of service with the company and a predecessor firm. **J. W. Brown** has replaced Hendrickson as field superintendent for the Hobbs producing area. Brown has been with the company since 1948.

THERE ARE ALL KINDS OF

CEMENT...



BUT JUST ONE BEST

CEMENT ADDITIVE

FOR OIL WELLS!

ONLY Strata-Crete 6 ® TRADE MARK

GIVES YOU ALL 6 !

This improved perlite cement additive generally ***lowers fill-up cost,*** and is ***easier to place*** (requires only normal pump pressures). ***Superior bridging qualities*** and light weight assure complete fill-ups, and the greater resiliency ***reduces fracturing and shattering.*** Strata-Crete 6 can be used with ***any type or brand of cement*** and in itself is ***not affected by high well temperatures.***

Strata-Crete 6 can be obtained from your oil well cementing service company.

GLC

GREAT LAKES CARBON CORPORATION

MINING & MINERAL PRODUCTS DIVISION — STRATA PRODUCTS DEPARTMENT

1404 NIELS ESPERSON BUILDING HOUSTON 2, TEXAS

▸ **John H. Douma,** manager of joint operations for Sunray Mid-Continent Oil Co., Tulsa, has been named vice-president and manager of the company's West Coast division, Los Angeles, succeeding **F. W. (Dick) Borden,** resigned.

Robert W. Griffith, formerly a special production department assistant to **R. E. Foss** since 1956, will replace Douma at Tulsa, Oklahoma.

J. H. Douma

F. R. Schmieder

▸ **F. R. "Dutch" Schmieder** of Shell Oil Company, has been named chairman of the Pacific Coast District Committee of API.

▸ **W. B. Beall,** division land superintendent for Continental Oil Company's central region land department has been promoted to assistant central region land superintendent. **T. E. Wells,** Fort Worth, Texas, general landman, succeeds Beall. **W. W. Blair,** Ardmore, Oklahoma, assistant division land superintendent, promoted to division land superintendent.

Keith T. Webb, Harvey, Louisiana, has been promoted to assistant regional geologist for the CATC marine region. He was formerly district geologist for that region and **Douglas E. White,** Harvey, geologist, will succeed Webb.

▸ **Karl F. Hagemeier** has been promoted to the position of vice president in charge of Gulf Coast operations for Texas Crude Oil Company. Hagemeier has been with the company since 1956.

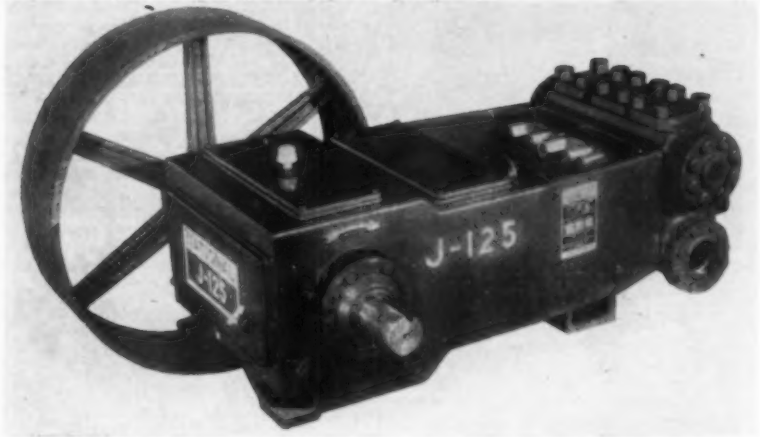
▸ At the annual meeting of the Alberta division of the Canadian Petroleum Association, Calgary, **J. B. Webb,** production department manager and exploration manager of Canadian Oil Companies, Limited, was elected chairman of the association's Alberta board of directors. **C. S. Lee,** president, Western Decalta Petroleum Limited, was electd first vice-chairman and **A. O. Detmar,** president and general manager, Mobil Oil of Canada, Ltd., was named second vice-chairman. Retiring chairman of the board is E. C. Babson, Union Oil Company of California.

▸ Major changes in the management of Beaver Lodge Oil Corporation are: **William H. Hudson,** of Dallas and New York City, independent oil operator and investor, was elected president and chairman of the board. **Joseph B. Avant,** independent geologist of Dallas, Texas, was named vice-president and **B. G. Fuller** was elected secretary-treasurer. **Stewart Bennett** has been appointed general manager of company operations. New directors are **Hudson, Eugene V. Klein** and **Burt Kleiner** of Beverly Hills, California, **Thomas R. Hartnett III,** Dallas attorney, and **Lee Van Atta,** also of Dallas. **Merle Thorpe,** former president of the company, remains a director.

It's New

Drilling – Producing Equipment

New Triplex Pump Rated at 125 HP



National Supply has developed a new triplex pump, rated at 125 input hp, which is available with fluid ends for low pressure-high volume, medium pressure-medium volume, and high pressure-low volume service. The J-125 is intended for water flooding and salt water disposal, and as a power-oil source for sub-surface hydraulic pumping systems. It also is suitable for high pressure testing, gathering service, formation fracturing, and acidizing. *The National Supply Company.*

Circle number (1) on reply card.

Portable Mud Testing Kit

A new rig lab to aid in solving drilling mud problems has been announced by Magcobar. The unit contains a mud balance with three scales, a stopwatch with cover, a plastic viscosity funnel, all necessary reagents and equipment for chemical tests, and a filter press for water-loss determinations. The kit measures 27 by 19 by 12 in. and weighs only 65 lb. It can be mounted on a table or on hangers. *Magnet Cove Barium Corporation.*

Circle number (2) on reply card.

Sucker Rods for Slim-Hole Completions

Axelson has avaliable a new ½-in. sucker rod and a 1-in. OD coupling designed primarily for application in slim-hole completion wells. The rod is of carbon manganese material and available in 25-ft lengths with ⅝-in. wrench flats. Maximum 1-in. diam on the joint provides adequate fluid passage when used in tubing as small as 1¼-in. ID. *Axelson Manufacturing Company.*

Circle number (3) on reply card.

Highly Flexible Drilling Hose

A new rotary drilling hose, announced by B. F. Goodrich, has more than 2 miles of cable spiralled inside every 60-ft length. Two plies of extra heavy wire furnish resistance to extreme bottom-hole pressures. The highly flexible hose has built-in couplings and extra plies of wire and fabric to protect against bending stress at the coupling. *B. F. Goodrich.*

Circle number (4) on reply card.

Chemical-Resistant, Non-Skid Coating

Non-skid surfaces, plus resistance to chemicals, is available with a new product from Grant Chemical. The product, Ken-Kote, has greater impact strength than concrete and 3 times its abrasion resistance. The surface is non-porous, non-absorptive and not affected by salt spray, acids, oils, or concentrations of 50 percent caustic soda. *Grant Chemical Company, Inc.*

Circle number (5) on reply card.

Split-Flapper Check Valve

The Garrett Corporation has a newly-designed split-flapper check valve which is adaptable to operational temperatures from cryogenic levels to 1000 F. Twin flappers, opening in the direction of flow, are supported through the center of the pipe. Spring mounting causes fast closing. It can accommodate lines from 1 to 12-in. in size. *The Garrett Corporation.*

Circle number (6) on reply card.

Single Prism Stereoscope

A rugged, light, single-prism stereoscope for use in the field or in the office provides a simple system for study and analysis of stereoscopic photographs. Weighing less than 2 lb, the unit is easily carried in a canvas carrying case and folds flat for easy handling. Viewing prism is automatically aligned when the case is opened. *Booklime, Inc.*

Circle number (7) on reply card.

Thread Locking Compound Eliminates Tack-Welding

Halliburton is offering a thread locking compound called Howco Weld which has proved superior to tack-welding for permanently locking threaded connections. The compound is unaffected by temperatures up to 475 F. To break out a connection, once the compound is set, the connection must be heated to 550 F with a welder's torch. *Halliburton Oil Well Cementing Company.*

Circle number (8) on reply card.

LACT Unit for Small Leases

A skid-mounted LACT unit manufactured by Murdock has a 3-bbl positive meter tank with 10-bbl receiving tank for pipeline delivery. Its accurate measuring capacity is 3 to 500 bbl per day. The system, with control panel rack-mounted, has the same instrumentation, BS&W monitor, and controls as larger units. Auxiliary connections are provided for the use of lease valve, automatic sampler, flood lighting, and well controls. *Murdock Tank & Manufacturing Company.*

Circle number (9) on reply card.

DON'T WELD on CASING!

WHY? Because field tests made on "average" oil field welding for mounting scratchers and centralizers have shown a great variation in weld quality, and damage from undercutting, hard spots, and electrolytic corrosion. Now there is no longer any need to depend entirely on welding for scratcher and centralizer installations with possible damage to valuable equipment. You can completely eliminate welding on casing, and at the same time get an economical scratcher and centralizer installation that will not interfere with normal casing running practice . . .

B and W AUTOMATIC STOP COLLARS

Just Slide Them On and Drive Slips Flush with Casing.

Also use B and W Thread-Lock Cages and B and W Thread-Lock Cement to eliminate welding on bottom joints to prevent unscrewing as drilling continues.

ANOTHER FIRST BY THE FIRST NAME IN PRIMARY CEMENTING TOOLS

OTHER B and W PRODUCTS:

Multi-Flex Scratchers • Nu-Coil Scratchers • Rotating Scratchers, Multi-Flex and Nu-Coil Types • Automatic Stop Collars • Stabilizers • Rotator Collars • Liner Centralizers • Latch-On Centralizers.

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106

New Equipment

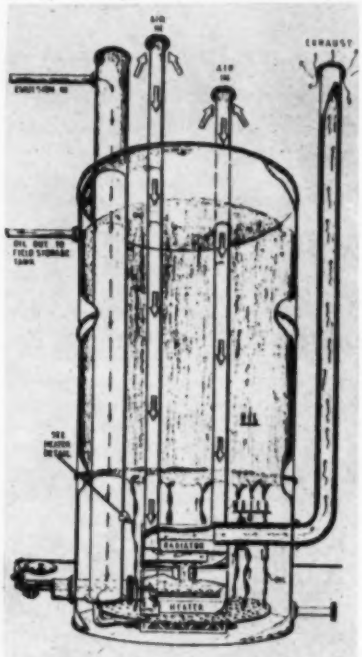
Pumper Features New "Geometry"

A new type pumping unit manufactured by Oilfield Equipment Corporation features a unique torque reduction system. A front-mounted reducer makes the unit similar in operation to the air balanced unit, but instead of an air system, the unit employs rotating counterweights, resulting in near continuous torque loading and reduction of peak torque. The unit also features automatic counterbalancing. *Oilfield Equipment Corporation of Colorado.*

Circle number (10) on reply card.

Submerged Heater for Water Knockout

Space Corporation has developed a new type of gas-burning heater which will satisfy the requirements of either the gun-barrel process or the heater-treater process. It supplies constantly-controlled heat within a 4-deg tolerance at any preset temperature. The heater is designed for complete submersion, except for the ends of the exhaust and intake stacks, which can be as much as 200 ft from the unit. The unit is available in sizes ranging from 30,000 to 1.5 million Btu input capacity. *Space Corporation.*



Circle number (11) on reply card.

Anti-Seize Sealant

A new anti-seize sealing compound introduced by Armite Laboratories stops spiral leaks from large diameter threads and coarse fittings and in welded flanges that have become distorted. Operating limits range from minus 350 F to 2900 F and up to 50,000 psi. *Armite Laboratories.*

Circle number (12) on reply card.

Valve With O-Ring Seals

Stockham announced a new non-lubricated general purpose valve with two Teflon "O" rings in the face of the plug. Because of the double pressure-sealing effect of the rings, the upstream as well as the downstream seats hold bubble-tight against line pressure. *Stockham Valves & Fittings.*

Circle number (13) on reply card.

SECONDARY RECOVERY
Since 1922

PETROLEUM ENGINEERS
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Water Flooding **Gas Repressuring**
EVALUATION CORE ANALYSIS
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CLEAN OUT CHOKING SAND

Excessive sand and sediment holds back your oil. For fast, easy cleanout with fewer round trips and less downtime, use world famous Miller Sand Pumps.

Write for descriptive price list.

SAND PUMP SIZES IN STOCK

O.D.—2½, 3, 3½, 4¼, 5, 5½, 7 in. Lengths, 20, 25, 30 ft.

Composite Catalog Page 3419

MILLER SAND PUMPS

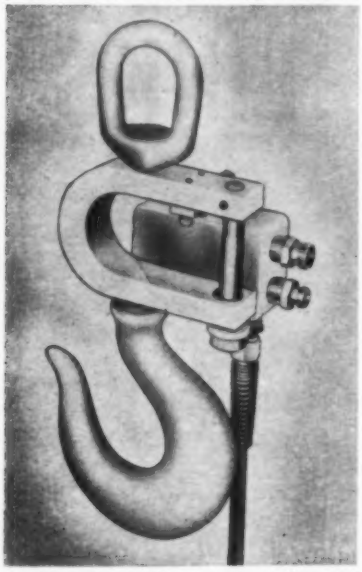
Miller Sand Pump Co.
General Offices, Box 4516
Oklahoma City 9, Okla.

EXPORT OFFICES
30 Rockefeller Plaza
NEW YORK 20, N. Y.

New Literature

Hoist Safety Switch

A new bulletin describes the Dillon Dyna-Switch which automatically cuts the power supply when a hoist approaches the



overload stage. Photos, schematics, and text describe the switch operation, give prices, and outline applications for safeguarding personnel and equipment. *W. C. Dillon & Company, Inc.*

Circle number (15) on reply card.

BS&W Monitor

United Engineers offers a bulletin describing the company's BS&W monitor known as the Monitron. Complete operating specifications of the unit are given along with diagrams of the unit itself and its relation to the transfer system. *United Engineers, Inc.*

Circle number (16) on reply card.

Tubing Safety Valve

Camco's Type A tubing safety valve is described in a new bulletin which presents construction features of the storm choke and includes sample calculations of closing pressure differentials under several conditions for the 2 by ½-in. valve. *Camco.*

Circle number (17) on reply card.

Pulsation Dampeners

Ball Manufacturing Company outlines the specifications of two types of pulsation dampeners in a new bulletin. The bulletin includes schematic drawings, dimensions, parts lists, and recommended installations for both Type AD and Type BL units. *Ball Manufacturing Company, Inc.*

Circle number (18) on reply card.

Liquid Level Control Switch

A new brochure published by Instruments, Inc. presents a positive displacement type float switch known as Mic-O-Flex. The bulletin outlines principle of operation, specifications, models available, and typical applications of the switches. *Instruments, Inc.*

Circle number (19) on reply card.

New Jensen Rotary Jack Offers: FAST, EASY INSTALLATION

This new **Jensen Rotary Jack** features *floor-clearing* cranks and weights, permits installation on flat concrete surfaces or simple steel skids. Completely eliminates the need for expensive special foundations and crank weight wells.

And it's a breeze to counterbalance. Just one man — standing on the ground — can easily adjust the rack-and-pinion counterbalance system — without special equipment.

Get all the facts for yourself. **Call, wire or write for free catalog — today!**

STOCKED BY YOUR LOCAL SUPPLY STORE

Made by **JENSEN BROS. MFG. CO., INC., P. O. Box 477-B, Coffeyville, Kansas**

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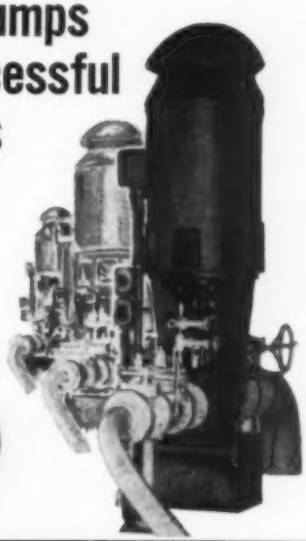
JENSEN JACKS

FIELD-PROVEN
Johnston Pumps team up for Successful Water Floods

Both Injection and Supply

Pumps are installed in multi-unit stations to provide COMPLETE SYSTEM FLEXIBILITY with a wide range of pressure-capacity combinations.

Pressures to 2500 psi.



1909-1959 50 YEARS JOHNSTON PUMP COMPANY

Send today for colorful bulletin.

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A Division of
The Youngstown Sheet and Tube Company
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Johnston Pump Co.
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Send complete information on water flood applications:
Name_____
Address_____
Firm_____

FOR HIGH EFFICIENCY OPERATION
MARTIN-DECKER
SPEED SELECTOR

Time To Be Using The Low Drum Clutch

If, at start of hoisting, the needle comes to position as shown, the draw works should be in high transmission speed and using the low drum clutch.

Time To Be Using The Hold Down Clutch

When sufficient pipe has been pulled (reducing the total weight) to bring the needle to point shown, it is time to shift to low transmission speed and use the high drum clutch.

Time To Be In High Gear

At this point it is time to change to second transmission gear and later as the pointer falls off shift to high gear.

The Martin-Decker Drawworks Speed Selector is used in the Type "D", "E" and "F" Weight Indicators. It automatically interprets the tension in the dead line and indicates directly the proper drum clutch and transmission clutch for the fastest and most efficent drawworks operation.

The Speed Selector *prevents*:

A. Speed ratios which are too high for the load with consequent overloading of chains, clutches and engines.

B. Speed ratios which are lower than the load requirements with subsequent loss of time.

The Speed Selector *provides*:

A. The most efficent use of rig equipment.

WRITE FOR DESCRIPTIVE LITERATURE

MARTIN-DECKER CORP.
HOME OF THE WEIGHT INDICATOR
LONG BEACH, CALIFORNIA

New Literature

Data Processing Information

A new system of punched-card data processing is described in a folder published by Remington Rand. The system, designed for small businesses, consists of four components: Alphabetical punch, sorter, alphabetical tabulator and summary punch, and reproducing punch. Operation is at 60 card per min and can be adjusted to perform faster. *Remington Rand Univac Division.*

Circle number (20) on reply card.

Friction and Fluid Drives

Twin Disc Clutch Company's new bulletin gives condensed specifications on all the company's friction and fluid drives. The bulletin uses engineering data, schematics, dimensions, and other information to describe friction clutches, power take-offs, reduction gears, fluid couplings, torque converters, and marine gears. *Twin Disc Clutch Company.*

Circle number (21) on reply card.

Booklet Helps Save Drill Pipe

A new, revised edition of a booklet entitled "How to Make Drill Pipe Last Longer" is available from National Supply. The booklet covers causes and remedies for fatigue weakening of drill pipe, including plastic coatings, hardfacing, proper handling, corrosion inhibitors, and use of drill collars. *The National Supply Company.*

Circle number (22) on reply card.

Catalog of Oil Field Diesel Equipment

The complete product line of drilling engines, diesel-electric power plants, and engine-generator sets made for oil field applications by White Diesel Engine division is described in a 20-page bulletin issued by the firm. The catalog summarizes performance characteristics of 26 engine models and includes photos, cutaway and dimensional drawings, graphs, and specification tables for ready reference. *White Diesel Engine Division.*

Circle number (23) on reply card.

Folder Outlines Cement Locator Log

A folder from Lane-Wells outlines the company's new Cemoton service which locates cement columns and tops in new or old wells, regardless of age. Run with other nuclear logging services, the Cemoton responds to the density of material surrounding the casing and can be used to determine the effectiveness of primary cement jobs as well as to check a squeeze job. *Lane-Wells Company.*

Circle number (24) on reply card.

Guiberson Announces New Equipment Catalog

The Guiberson Corporation has announced a new catalog for 1959 and 1960 containing full descriptions, detailed engineering data, complete parts price lists and numerous illustrations of its oilfield equipment. The 172-page book includes setting and removal procedures and a surface setting stroke table for each type of packer offered. *The Guiberson Corporation, one of the Dresser Industries.*

Circle number (25) on reply card.

SHORT STUBBY LINKS

another reason why TM HI-TEST CHAIN is preferred throughout the oil fields

Makers of TM truck tire chains

TM Hi-Test Chain has short, stubby links for greater flexibility—better grips. Made from high-tensile carbon steel and heat-treated to assure uniform properties . . . finer grain . . . greater strength and longer wearing qualities. Patented Tayco Hooks—the strongest on the market—are furnished with TM Hi-Test Boomer Chain. Call your supply store or write for Oil Field Bulletin.

S. G. TAYLOR CHAIN CO., INC.
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Taylor Made CHAIN SINCE 1873

1. FABRICATION of all types of equipment (Fractionating Columns, Gas Columns, Pressure Vessels, Plate and Heavy Steel Work, Special Machines, Autoclaves, Shells, Bridge Girders) is performed to order, to specification.

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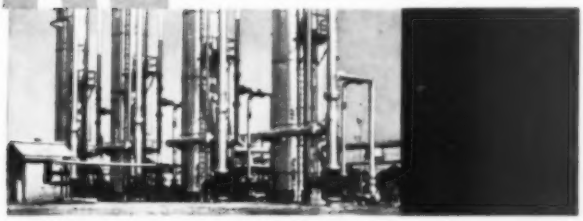
3. STAINLESS—Separate, integrated shop for stainless fabrication protects against contamination by ordinary steel.

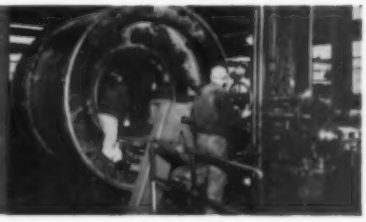
4. DELIVERY by rail, truck or inland, coastal or overseas waterway.

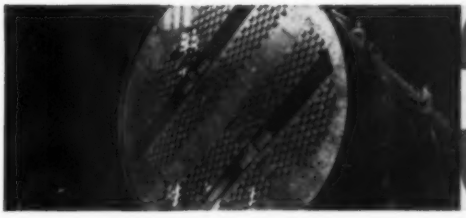
POTENTIAL

1 FABRICATION



2 MACHINING





3 STAINLESS

4 DELIVERY

Through integrated, efficient operation, Sun Ship can reduce costs, increase your POTENTIAL. Call for an estimator or representative.

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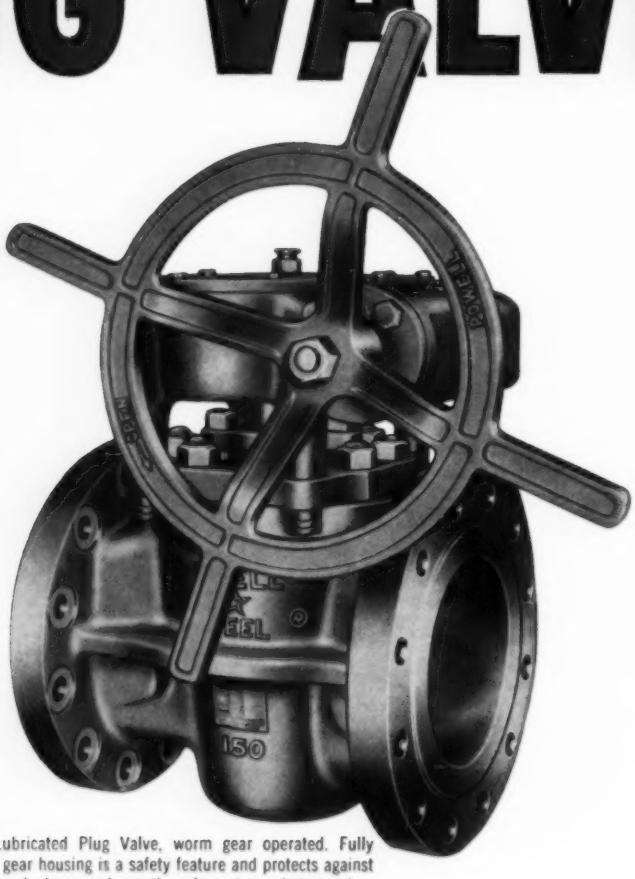
POWELL

LUBRICATED PLUG VALVES



Powell Lubricated Plug Valve, worm gear operated. Fully enclosed gear housing is a safety feature and protects against injuries and damage from the elements and tampering.

Like all Powell Valves, Powell Lubricated Plug Valves are superior in their field . . . and have many advantages over conventional types of Valves:

- Simple design: Only three basic parts—Body, Bonnet, Plug.
- Quick, complete shut-off.
- Tapered plug assures positive seating.
- Machined surfaces of plug and body are not exposed in open position.
- Cavity-free straight passage assures streamlined flow.

Powell Lubricated Plug Valves are available in sizes ¼" through 16", depending on the type required—Semi-steel 175 and 200 pounds WOG; Carbon Steel ASA 150 and 300 pounds.

Powell can also furnish Lubricated Plug Valves in other alloys on special order.

For all your valve needs, consult your local Powell Distributor—or write directly to us. Send for our new Lubricated Plug Valve Catalog, Number PV-5.

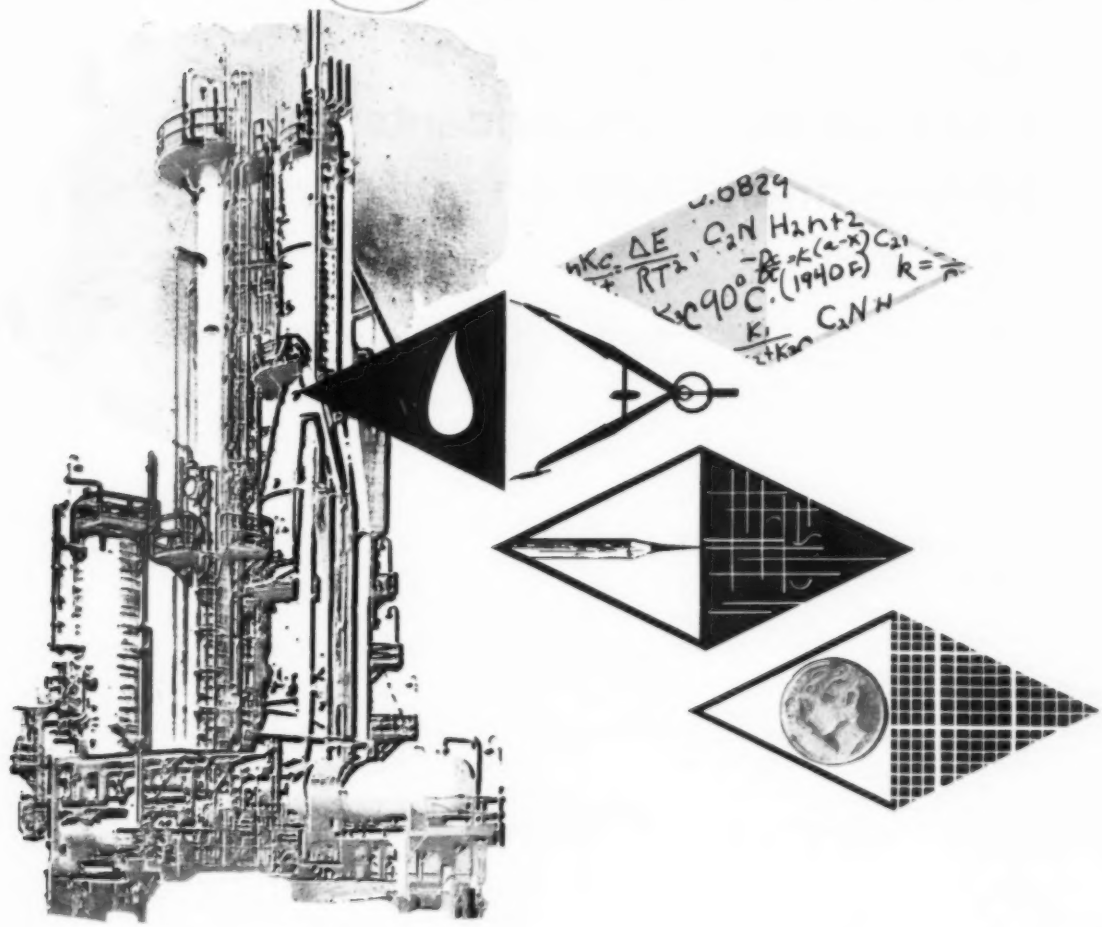
The Wm. Powell Company • Cincinnati 22, Ohio

Dependable Valves Since 1846

POWELL...world's largest family of valves

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

intangibles were never so important



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Worker recruiting and training . . . special safety programs . . . on-the-spot solutions to pressing problems . . . these and other extras are included in Procon service. Applying such intangibles to construction of petroleum, chemical and petrochemical plants is the specialized function of Procon. Modern, efficient construction techniques form but a part of the precision construction system developed by Procon. That is why a Procon-built plant can be depended upon to more than meet specifications.

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WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

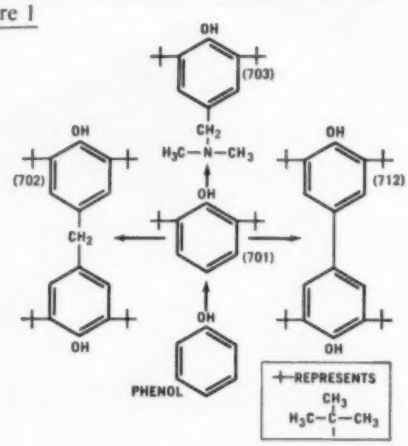
Discovery of "Ortho-Alkylation" reaction makes possible a new series of antioxidants for petroleum and petrochemical products

ETHYL'S DISCOVERY of the "ortho-alkylation" reaction has made available commercially, for the first time, a whole new series of phenol and aniline derivatives alkylated in the two and six positions.

All of these compounds are excellent chemical "building blocks" because of the open reactive para position on the benzene ring. (Figure 1)

Exhaustive evaluation has shown that many of these compounds have superior antioxidant characteristics in specific petroleum product applications.

Figure 1



Phenol and iso-butylene are combined by Ethyl's patented "ortho-alkylation" process to form 2,6-di-*tert*-butylphenol (701). This compound, with the open reactive para position, is a chemical "building block" for other important additives.

"Ethyl" Antioxidant 701— A Gasoline and Jet Fuel Additive

One of these compounds, 2,6-di-*tert*-butylphenol, is an excellent gasoline and jet fuel additive for inhibiting the formation of gum and other oxidation products. This compound is available commercially as "Ethyl" Antioxidant 701 and in a more economical form as "Ethyl" Antioxidant 733.

The importance of 2,6-di-*tert*-butylphenol is increased by the fact that its derivatives contain the hindered phenol structure which is characteristic of effective phenolic antioxidants. This led Ethyl Research in the direction of many possible additives.

701 Also an Intermediate to Other Additives

Early work showed that a highly effective structure pointed to a compound in which the two and six positions were occupied by *tert*-butyl groups. The four position was then used to test substituents in experiments designed to modify the 2,6-di-*tert*-butylphenol structure in order to obtain improved antioxidants.

"Ethyl" Antioxidant 702. A Lubricant Antioxidant and Anti-Wear Agent

Lubricant applications involve elevated temperatures and aeration and thus it was desirable to examine structures having minimum vapor pressures. This suggested compounds with higher molecular weights that still retained desirable antioxidant properties.

One important additive resulting from this work is 4,4'-Methylenebis(2,6-di-*tert*-butylphenol) ("Ethyl" Antioxidant 702), an exceptional lubricant antioxidant. It is a low volatility, non-sludging, temperature-stable, phenolic antioxidant and anti-wear agent.

Numerous laboratory and field tests were used in examining the characteristics of "Ethyl" Antioxidant 702:

Antioxidant Evaluations

ASTM Steam-Turbine Oil Tests • Panel Coking Tests • Automatic Transmission Tests • CRC L-4 Tests • Modified Polyveriform Tests • EMD Silver Corrosion Test

Anti-Wear Evaluations

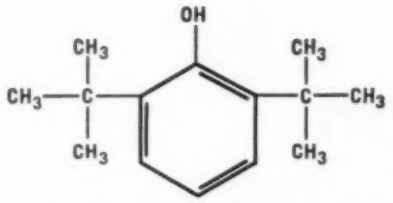
CRC L-4 Tests • Chevrolet "Full-Throttle" Tests • "Hot-Ring" Tests • CRC FL-2 Tests

"Ethyl" Antioxidant 702 has found application in crankcase oils for gasoline and diesel engines. Both oxidation and bearing corrosion are inhibited (Figure 2) and scuffing-type piston ring wear is minimized.

The compound is finding increased use in railroad diesel engine oils and in other applications where copper, silver and bronze parts are critical. In all evaluations, oil treated with "Ethyl" Antioxidant 702 showed outstanding improvement.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

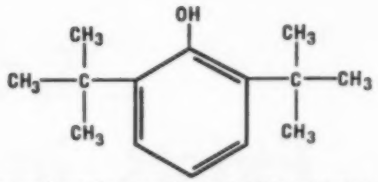
701—2,6-Di-*tert*-butylphenol



In motor and aviation gasoline to inhibit oxidation during storage; in jet fuels to inhibit oxidation during storage; and in industrial oils to inhibit oxidation.

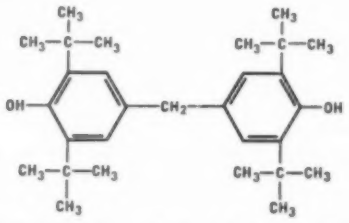
733—2,6-Di-*tert*-butylphenol (75% min) 2,4,6-Tri-*tert*-butylphenol (10-15%) Ortho-*tert*-butylphenol (10-15%)

(75% Min.)



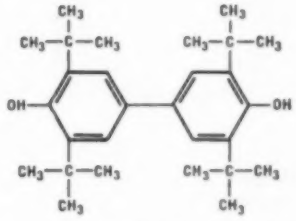
In motor and aviation gasoline to inhibit oxidation during storage; in jet fuels to inhibit oxidation during storage; and in industrial oils to inhibit oxidation.

702—4,4'- Methylenebis (2,6-di-*tert*-butylphenol)



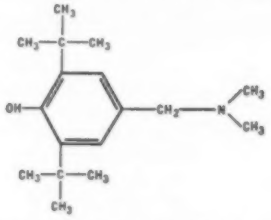
In motor oils for both gasoline and diesel engines to inhibit oxidation and minimize scuffing-type piston ring wear; in automotive transmission fluids and industrial oils to inhibit oxidation; and in plastics and rubbers to inhibit oxidation.

712—4,4'-Bis (2,6-di-*tert*-butylphenol)



In petroleum-based oils for high-output engines to inhibit oxidation and minimize scuffing-type piston ring wear; in diester-type synthetic oils to contro oxidation and deposit formation; and in plastics and rubber to inhibit oxidation.

703—2,6-Di-*tert*-butyl-α-dimethylamino-p-cresol



In motor oils, greases and industrial oils to inhibit oxidation and impart alkylinity, dispersancy, anti-rust and anti-wear properties; in diester-type synthetic oils to inhibit oxidation during storage.

EMD SILVER CORROSION TEST

Silver coupons from railroad diesel engine oil test at 275°F. for 72 hours.

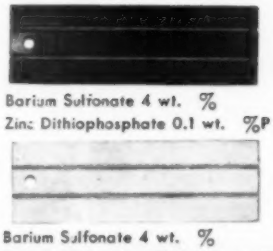


Figure 2

How Ethyl Research is helping you

Ethyl Research Laboratories are searching continuously for new and better additives for the petroleum industry.

The discovery of the "ortho-alkylation" reaction opened a new field of investigation. As a result, several excellent antioxidants are now available for a wide range of petroleum and petrochemical products.

Fact sheets are available through your Ethyl Representative, or by writing Ethyl Corporation, 100 Park Avenue, New York 17, N. Y.

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In refining and petrochemical plants:

Corrosion Exists in Many Forms

Three main types according to environment are: (1) Atmospheric (2) Fluid and (3) Soil Corrosion

John C. Kuli *Pittsburgh, Pennsylvania*
John L. McPherson *Chicago, Illinois*
Chemical Plants Division, Blaw-Knox Company

CORROSION is an industry-wide problem which is rapidly approaching the **staggering cost of $10 billion per year.** The process industries, including petrochemical industries, account for $1 billion of this cost. The refining industry individually accounts for $300 million.

Among the various ways in which corrosion results in monetary losses, the following are probably the most important:

1. Premature losses on capital investment;
2. Excessive plant and equipment maintenance cost;
3. Loss of product due to leaks or breaks;
4. Decreased production capacity due to shut-downs for equipment repair or replacement.

Since a reduction of these losses by only one percent would amount to an annual saving to the refining industry of $3 million, it is obvious that any attempt in this direction is well worthwhile. A wider understanding of the nature and mechanisms of the various forms of corrosion could result in substantial reduction of corrosion losses. It is with this hope that this article has been prepared.

Corrosion can be defined as the gradual destructive alteration of construction material by chemical or electrochemical reaction with its environment. Although non-metallic materials may fall within this definition, this article is limited to the discussion of the corrosion of metals and alloys. For the sake of completeness, a brief discussion of hydrogen blistering is included. Although it is not covered by the definition of corrosion, it results in the deterioration of structural materials, and is normally within the province of the corrosion or materials engineer.

ATMOSPHERIC CORROSION

Corrosion of metals by weathering, acid fumes, and water vapors varies from one locality to another, and depends entirely upon the composition of the surrounding atmosphere. Probably the most important single factor controlling the rate of atmospheric corrosion is the relative humidity or percent water vapor. It has been found that the corrosion of ferrous metals is almost arrested in atmospheres containing relative humidities of 30 percent or less.

Alternate wetting and drying of metal from condensation causes both electrochemical and chemical corrosion. Carbon dioxide, sulfur dioxide and hydrogen sulfide gases are ab-

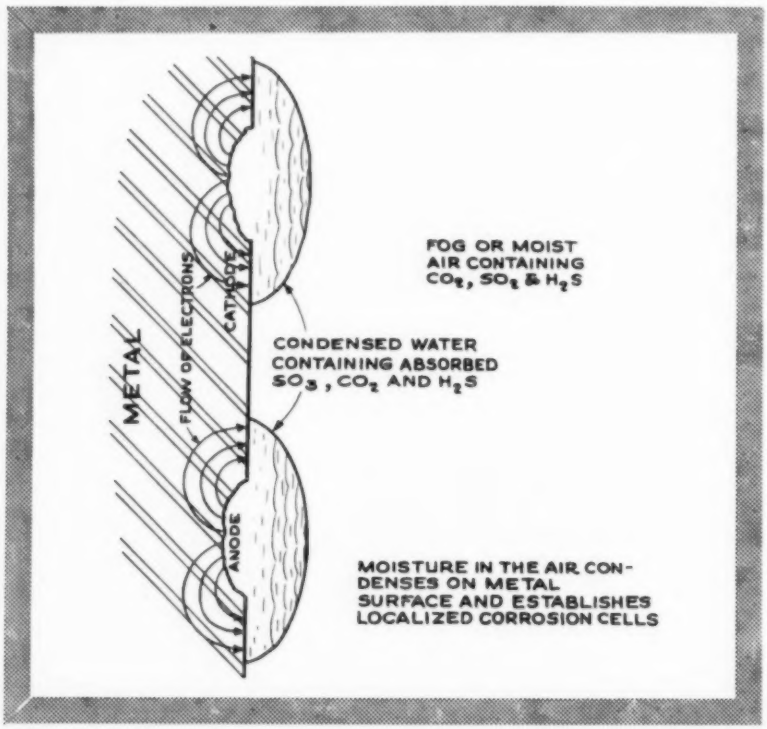

METAL
FLOW OF ELECTRONS
CATHODE
ANODE
FOG OR MOIST AIR CONTAINING CO_2, SO_2 & H_2S
CONDENSED WATER CONTAINING ABSORBED SO_3, CO_2 AND H_2S
MOISTURE IN THE AIR CONDENSES ON METAL SURFACE AND ESTABLISHES LOCALIZED CORROSION CELLS

FIG. 1. **Corrosion** of metals in humid atmosphere.

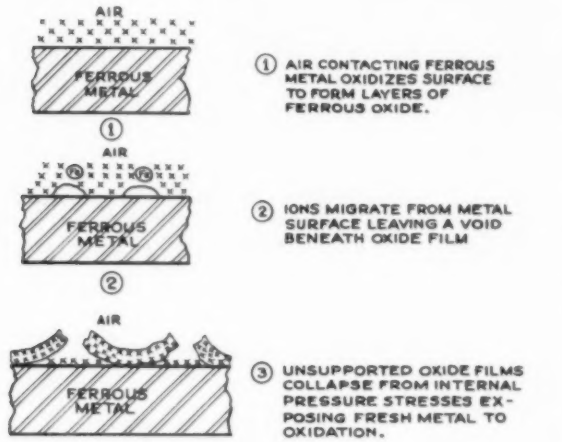

AIR
FERROUS METAL
1
AIR
FERROUS METAL
2
AIR
FERROUS METAL
1 AIR CONTACTING FERROUS METAL OXIDIZES SURFACE TO FORM LAYERS OF FERROUS OXIDE.
2 IONS MIGRATE FROM METAL SURFACE LEAVING A VOID BENEATH OXIDE FILM
3 UNSUPPORTED OXIDE FILMS COLLAPSE FROM INTERNAL PRESSURE STRESSES EXPOSING FRESH METAL TO OXIDATION.

FIG. 2. **Oxidation** of ferrous metal.

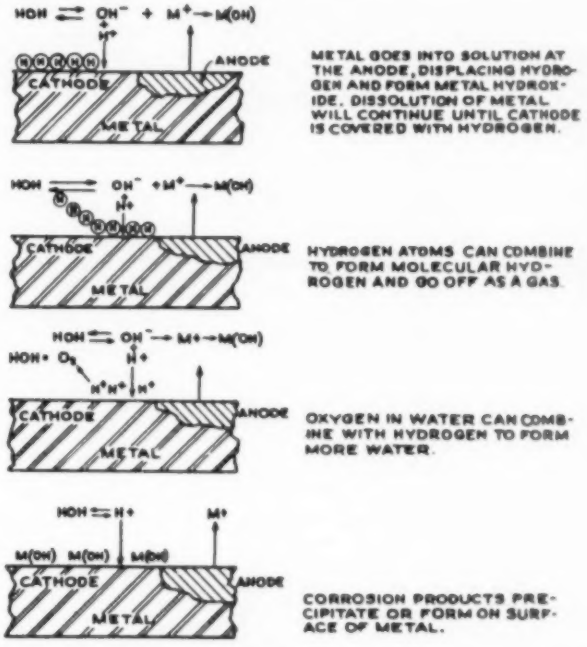

HOH ⇌ OH⁻ + M⁺ → M(OH)
H⁺
CATHODE
ANODE
METAL
METAL GOES INTO SOLUTION AT THE ANODE, DISPLACING HYDROGEN AND FORM METAL HYDROXIDE. DISSOLUTION OF METAL WILL CONTINUE UNTIL CATHODE IS COVERED WITH HYDROGEN.
HOH ⇌ OH⁻ + M⁺ → M(OH)
H⁺
H H H H H H
CATHODE
ANODE
METAL
HYDROGEN ATOMS CAN COMBINE TO FORM MOLECULAR HYDROGEN AND GO OFF AS A GAS.
HOH ⇌ OH⁻ → M⁺ → M(OH)
HOH + O₂
H⁺
H⁺H⁺ H⁺
CATHODE
ANODE
METAL
OXYGEN IN WATER CAN COMBINE WITH HYDROGEN TO FORM MORE WATER.

FIG. 3. **Fluid** corrosion of metal.

sorbed by condensed moisture to form dilute acids which serve as electrolytes that establish electrochemical corrosion illustrated in Fig. 1.

Atmospheric corrosion of metals resulting from contact with dry gases, such as oxygen, is almost entirely chemical. Clean, unprotected metal exposed to the surrounding atmosphere is merely oxidized and a film of oxides and other compounds is formed upon the surfaces. The rate of metal loss by oxidation may follow one of several paths depending upon the metal and the surrounding conditions. The initial rate of oxidation for most metals is very fast and independent of the mode followed.

After initial oxidation, the rate of increase in oxidation of certain metals may slow down to a constant rate so that further oxidation follows a rectilinear curve. With other metals the rate may cease so that further oxidation follows an asymptotic curve. More frequently, however, metals oxidize at a continuously decreasing rate so that the oxidation follows a parabolic or logarithmic curve.

In all cases, except where oxidation follows a rectilinear function, the oxide film formed upon the surfaces of the metal becomes more protective as it forms. It was originally believed that oxidation proceeded and was controlled by diffusion of oxygen through the oxide film. It is now believed that metal ions also move outward through the oxide film and become oxidized at the surface. Actually, both mechanisms probably occur during oxidation as shown in Fig. 2.

FLUID CORROSION

Fluid corrosion is almost entirely electrochemical, because all metals in contact with an electrically conducting fluid have a tendency known as the solution potential, to go into solution in the form of ions. Whenever this occurs, another metal or hydrogen ion must be displaced from the solution.

The ability of one metal to displace another from solution, and the probability of corrosion depends upon their solution potentials. Every metal in the electromotive series has a greater solution potential than those below it and will displace them from solution. In this series hydrogen behaves as a metal, and all common metals except copper will displace hydrogen from solution.

Typical of the corrosion of metals by fluids is that of cast iron or steel. Iron enters the solution by displacing hydrogen as illustrated in Fig. 3. The surface where iron enters the solution is known as the anode, and the area where hydrogen is displaced is known as the cathode. As long as there are hydrogen ions present, the corrosion process can continue. As it proceeds, however, hydrogen formed at the cathode is not immediately evolved and a gaseous layer is formed over the surface of the metal.

This layer of hydrogen gas interferes with the flow of electrons by preventing ionic hydrogen from contacting the cathode and receiving the electrons required to produce more nascent hydrogen. This reduction in the flow of electrons, called polarization, slows up the corrosion process.

Anything that interferes with the removal of hydrogen from solution slows up the corrosion process, while anything that aids in this removal speeds the process. The presence of oxygen or oxidizing salts in the solution can accelerate corrosion by combining with the hydrogen to form water. Oxygen can also reduce corrosion by oxidizing the metal to form an insoluble protective film on the surface of the metal.

The addition of an alkali reduces the corrosion of iron by decreasing the number of hydrogen ions present. Conversely, the addition of an acid accelerates corrosion by increasing the hydrogen-ion concentration.

Temperature is a major factor controlling the rate of corrosion by fluids. In general, a rise in temperature increases the rate of the corrosion process by increasing ionization and the mobility of all reacting phases.

Temperature may have an important effect upon surface film formation and its solubility. Those forming at one temperature may not form at another and, in general, the solubility of the film increases with increasing tempera-

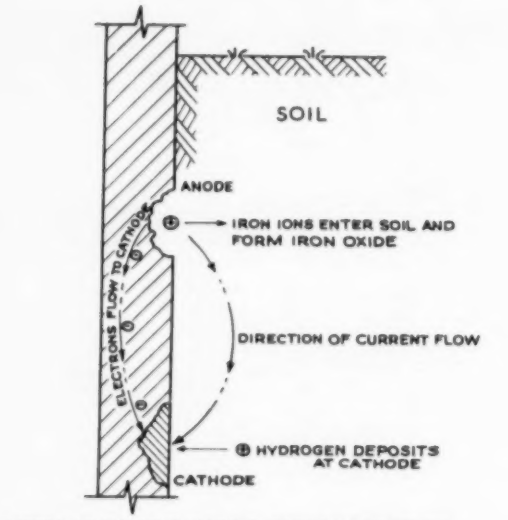

SOIL
ANODE
IRON IONS ENTER SOIL AND FORM IRON OXIDE
DIRECTION OF CURRENT FLOW
ELECTRONS FLOW TO CATHODE
HYDROGEN DEPOSITS AT CATHODE
CATHODE
METAL AT ANODE IS MORE ELECTROPOSITIVE TO SOIL THAN METAL AT CATHODE, THEREFORE, FERROUS IONS ENTER THE MOIST SOIL AND ARE OXIDIZED. SIMULTANEOUSLY HYDROGEN IONS MOVE TO CATHODE AND ARE RELEASED AS NASCENT HYDROGEN.

FIG. 4. **Corrosion** of steel in soil.

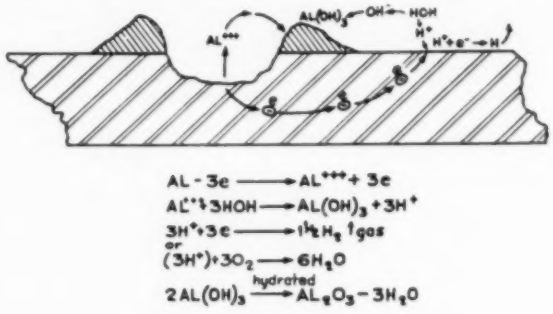


FIG. 5. **Pitting** corrosion of aluminum.

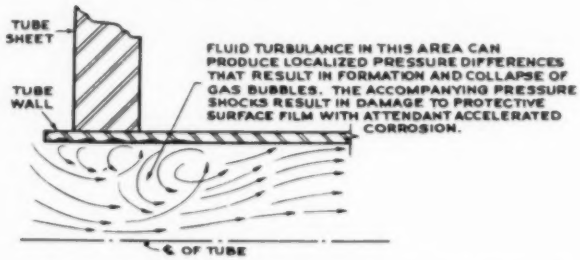

TUBE SHEET
TUBE WALL
FLUID TURBULANCE IN THIS AREA CAN PRODUCE LOCALIZED PRESSURE DIFFERENCES THAT RESULT IN FORMATION AND COLLAPSE OF GAS BUBBLES. THE ACCOMPANYING PRESSURE SHOCKS RESULT IN DAMAGE TO PROTECTIVE SURFACE FILM WITH ATTENDANT ACCELERATED CORROSION.
OF TUBE

FIG. 6. **Impingement corrosion** due to eddy currents at entrance of heat exchanger tube.

ture. Local differences in solution temperature may localize electrolytic corrosion in systems where it is negligible under uniform temperature conditions.

Fluids moving at high velocity can increase corrosion by damaging the protective film of corrosion products that form on the surface of a metal.

SOIL CORROSION

Underground corrosion of structures is largely a function of the soil in which it is located. Those containing water, oxygen, acids and anaerobic bacteria are the most corrosive. Dry soils having high electrical resistivity cause a minimum of damage to buried structures.

Black iron or steel placed in moist soil assumes an electrical potential with respect to the soil it contacts. Variations in soil composition and in the metal, result in different solution potentials at localized areas upon the metal surface. If the soil is sufficiently electrically conductive to permit the flow of current, an electrochemical corrosion process is established as shown in Fig. 4.

Aeration of the soil during excavation and backfill, or the presence of oxygen in the water accelerates corrosion by assisting in depolarization of cathodic metal areas. Pipelines and structures near grade elevation are most susceptible to this type of corrosion. Metal structures buried an appreciable depth, such as steel piling, very seldom corrode, because there is an insufficient amount of oxygen or oxidizing chemicals to depolarize the metal.

The acceleration of corrosion due to the presence of certain types of bacteria is not normally an important factor except in the case of swamps or land with a high water table.

FORMS OF CORROSION

One of the most common systems of classifying forms of corrosion is essentially based on corrosion mechanism. This classification includes uniform corrosion, pitting corrosion, stress corrosion, galvanic corrosion, intergranular corrosion, erosion corrosion, concentration cell corrosion, and fretting corrosion.

Each type has definite characteristics which allow identification by either visual or metallographic examination. A knowledge of the characteristic types together with plant operating service conditions will usually result in the solution of most corrosion failures.

UNIFORM CORROSION

Uniform corrosion is the most common form of attack, and is characterized by chemical or electrochemical reaction that proceeds uniformly over the entire exposed surface, as discussed in the opening paragraph. This form of corrosion undoubtedly represents the greatest amount of damage to metals, but is easily guarded against.

The solution to uniform corrosion problems is merely one of proper material selection, and the provision of adequate material thickness for the service-life desired. The use of more resistant materials, corrosion inhibitors, protective coatings, and cathodic protection or combinations of these expedients are frequently employed to solve uniform corrosion problems.

PITTING CORROSION

Pitting is highly localized electrochemical corrosion resulting from the breakdown of a passive film or nonhomogeneity in a metal. It can occur with any metal, but is most frequently encountered with passive metals like stainless steel and aluminum. It is characterized by well defined boundary lines that surround sharp depressions in the metal surface. Fig. 5 illustrates the pitting of aluminum.

Pits usually begin with the breakdown of a passive film at localized areas on a metal surface. This may be the result of imperfections or discontinuities in the surface film, such as the presence of impurities, inclusions and deposits of foreign material. It

may also result from mechanical damage such as indentations, scratches or introduction of foreign metal during fabrication.

This breakdown in the passive film is followed by the formation of an electrolytic cell in which the anode is a small area of active metal in the pit, while the cathode is the large surrounding passive area. The large potential difference of the "passive-active" cell accounts for a considerable flow of current and rapid corrosion at the anode or pit. While weak points and breaks in the passive film account for initial attack at localized areas, the subsequent course of corrosion is influenced by the potential difference arising from conditions within the metal itself, the characteristics of the solution in contact with the metal, and the presence of oxygen.

Localized corrosion at small anodic areas of the metal surface represents a high current density, but unless oxygen or an oxidizing salt is present in the solution to depolarize cathodic areas, corrosion may be stifled by hydrogen over-voltage. Pit growth, therefore, is controlled by the rate of cathodic depolarization. Also, as corrosion proceeds, there generally is a build-up of corrosion products over the pitted area. This tends to heal the break in the passive film and results in anodic polarization.

Pitting corrosion, in this case, is greatly influenced by the power of anions present in the solution to penetrate the passive film. The penetrating power of different anions decreases with increasing molecular size. In general, anions have the following sequence of penetrating power: Chlorides (most penetrating), bromides, iodides, fluorides, sulfates, nitrates, and phosphates (least penetrating).

Penetration of the film by anions leads to dissolution of the metallic atoms to which the protective film was originally attached. Such undermining loosens the film and permits corrosion to proceed. This results in the build-up of corrosion products in the form of a nodule over the pit, which is usually ineffective in stopping corrosion because of its porous structural make-up.

Strong oxidizing chemicals, silicates and colloids added to inhibit corrosion may promote pitting if added in insufficient concentrations. This is especially true when materials are used in borderline applications and poor control over inhibited corrosive solutions is maintained.

The proper use of inhibitors can reduce and eliminate pitting by aiding in repair and maintenance of a passive film. Also, aeration and agitation of a solution can be beneficial in maintaining a passive film on aluminum and stainless steel. The addition of a foreign metal or metallic compound into a corrosive medium frequently causes pitting corrosion. This is especially true of aluminum which is near the top of the electromotive series and can displace most metals from solution.

The Authors

John C. Kuli

John L. McPherson

John C. Kuli *is materials engineer in the Chemical Plants Division of Blaw-Knox Company at Pittsburgh, Pennsylvania. He holds a BS degree in chemical engineering and mechanical engineering from The University of Pittsburgh. He was with the U. S. Bureau of Mines from 1948 to 1949 in research and development of jet fuels. In 1950, he joined American Cyanamid Company in process engineering, and in 1951 was with H. J. Heinz Company. From 1952 to 1953, he was a piping engineer for Rust Engineering Company, and in the latter year, joined Callery Chemical Company. In 1955, he joined Blaw-Knox Company's Chemical Plants Division where he has served as a design engineer, a consulting materials and corrosion engineer, responsible for all corrosion research. He is a member of NACE, AIChE, ASM, Pennsylvania Society of Professional Engineers, and a registered professional engineer of Pennsylvania.*

John L. McPherson *is a district engineer at Chicago for the Chemical Plants Division of Blaw-Knox Company. He holds a BS degree in chemical engineering from West Virginia University, and has done graduate work at the universities of Cincinnati and Pittsburgh in chemical and metallurgical engineering. Since graduation, he has worked with the Crucible Steel Company in quality control; Wright Aeronautical Corporation in metallurgical engineering; with Vulcan Copper and Supply Company as a chemical engineer, and with Smith Douglas Company as a project engineer. He joined the Chemical Plants Division of Blaw-Knox Company in 1946. He has handled the design and engineering of vessels and heat exchangers, mechanical equipment, selection of construction materials for plants, and was previously a consulting materials engineer. He is a member of NACE, ASM, member, Joint Committee of ASTM-ASME for "Effect of Temperature on Metals," and is a professional engineer in the state of West Virginia.*

Pitting corrosion is one of the most serious forms of corrosion because it takes place with great rapidity and failure occurs by perforation of a relatively small area. Pitting is also difficult to evaluate and as a result it is almost impossible to predict equipment life.

STRESS CORROSION

Stress corrosion cracking of a metal is ascribed to the failure of a metal as the result of the combined action of stress and corrosion in which an intergranular attack or pitting may act as a stress raiser at the point of failure.

With copper alloys it is usually called season cracking and with carbon steels subjected to alkaline solutions it is described as caustic embrittlement.

Stress corrosion cracking is one of the most serious forms of corrosion because failure occurs suddenly and without warning. The period of time required for cracking varies from a few minutes to several years after initial exposure in a corrosive environment. Usually the more severe the corrosive medium and the higher the stress, the faster cracking will occur. Almost every metal system is known to be susceptible to stress corrosion cracking in some environment. Environments known to cause stress corrosion cracking of commonly used metals are listed in Table 1.

TABLE 1. Environments Known to Cause Stress Corrosion Cracking.

Metal	Corrosive
Carbon and Low Alloy Steel	Hydrogen Sulfide Sodium Hydroxide Nitrate Solutions Hydrogen Cyanide Solutions Mixed Acids (H_2SO_4 - HNO_3)
Stainless Steel	Acid Chloride Solutions Hydrogen Sulfide
Copper Alloy	Ammonia Vapors and Solutions Mercury Compounds Amines
Aluminum	Sodium Chloride Solutions
Nickel Alloys	Caustic Soda Hydrofluoric Acid

The phenomenon of stress corrosion cracking has been known to exist for more than half a century and several theories have been advanced to explain the mechanism of attack.

All of these theories agree as to the rate of corrosion but differ as to the part played by stress.

Stress corrosion produces a brittle type failure that may be classified into two categories; intergranular and transgranular cracking. Intergranular failures occur when the cohesion is reduced appreciably by chemical attack.

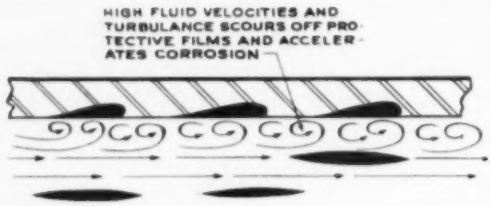


FIG. 7. **Fluids flowing** at high velocity produce eddies at pipe surface.

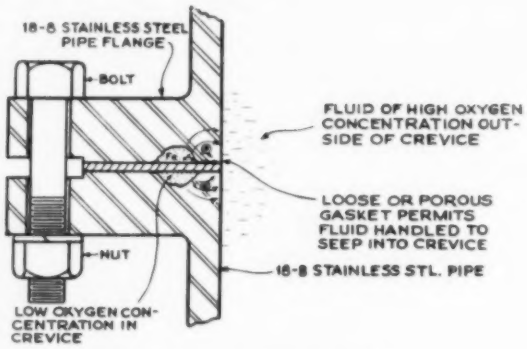

18-8 STAINLESS STEEL PIPE FLANGE
BOLT
FLUID OF HIGH OXYGEN CONCENTRATION OUTSIDE OF CREVICE
LOOSE OR POROUS GASKET PERMITS FLUID HANDLED TO SEEP INTO CREVICE
NUT
18-8 STAINLESS STL. PIPE
LOW OXYGEN CONCENTRATION IN CREVICE

FIG. 8. **Oxygen** concentration cell.

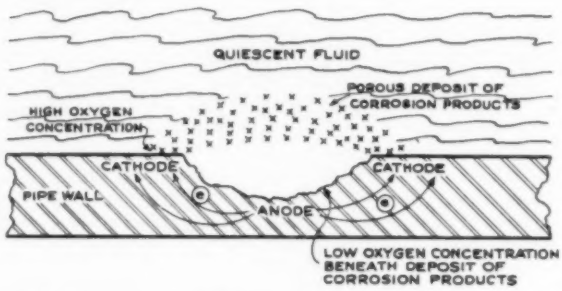


FIG. 9. **Concentration cell** corrosion of pipeline handling quiescent fluids which permit porous deposit of corrosion products.

and cracking predominantly follows the grain boundaries.

Transgranular failures result when cleavage of the grains occurs. Both types of failure are readily recognized by the branching characteristics of the cracks, and cracking always proceeds perpendicular to the direction of maximum tensile stress.

The stresses responsible for cracking are usually residual stresses induced by poor design or formed during fabrication and welding of the metal, or applied stresses resulting from internal pressure, thermal expansion, or thermal gradients across a metal cross section. These must be tensile stresses, since compressive stresses have never been known to cause stress corrosion cracking.

GALVANIC CORROSION

Corrosion resulting from contact between dissimilar metals exposed to an electrically conducting fluid is termed "galvanic corrosion." This is an electrochemical form of corrosion which results in accelerated attack of the least noble of the coupled metals and a decreased rate of attack of the more noble metal.

The "galvanic series of metals" indicates the tendency of metals to corrode galvanically. Whenever dissimilar metals are used in contact with each other and are exposed to an electrolytic solution, it is desirable to select combinations of metals that are as close together as possible in the galvanic series. If metals from the same or adjacent groupings cannot be used, then the part having the smallest surface area should be fabricated from the most noble material. Fastenings, valve trim, pump wear rings, and other similar equipment parts should always be made from the most noble metals.

In locating equipment such as vessels and pumps in a chemical processing plant it is good practice to keep equipment constructed from dissimilar metals separated as far apart as possible. Complex galvanic cells may exist when adjacent equipment is fabricated from dissimilar metals that are widely separated in the galvanic series. Corrosion from this cause is rare since the electrolytic cell is weak.

Galvanic corrosion can be prevented by disrupting the flow of current. In pipelines this is accomplished by using insulated flange assemblies or couplings between dissimilar metals. It can be minimized by designing equipment and structures in a manner that will not permit condensation or trapping of an electrically conducting fluid at bimetal joints. Free air circulation should be provided to hasten drying wherever dampness may be present.

An important means of preventing galvanic corrosion is cathodic, or galvanic, protection.

INTERGRANULAR CORROSION

The exact nature of intergranular corrosion, wherein a severe attack occurs along the grain boundaries of a metal, is still under investigation. It can occur with almost all metals under specific conditions. Intergranular corrosion may occur in some stainless steels that have been heat treated or subjected to temperatures between 750 to 1500 deg.

Intergranular corrosion is frequently caused by welding, thermal forming, or stress relieving of austenitic stainless steel. During welding there always is a thermal gradient along the welded metal surface which ranges from the melting temperature of the alloy to the atmospheric temperature of the base plate. There is a zone just out from, and surrounding the weld, in which the temperature is in the critical range of 750 to 1500 deg for a maximum period of time.

In this zone chromium carbides precipitate along the grain boundaries. As a result the area adjacent to the boundary is depleted in chromium. Conditions are now perfect for the formation of a galvanic cell in which the impoverished grain boundaries are anodic to the interior of the crystal. This type of attack may be reduced or eliminated by the use of stabilized alloys or alloys having a carbon content not in excess of the solid solubility limit (0.03 percent for all practical purposes).

EROSION CORROSION

Most metals rely upon a thin surface

film of corrosion products for corrosion resistance. This film may be an oxide as in the case of austenitic stainless steels in contact with nitric acid, or it may be a sulfate as in the case of cast iron and lead with sulfuric acid. But, no matter what the composition, the presence of a film reduces corrosion by polarizing anodic areas on the metal surface.

Any mechanism which removes or damages this film accelerates corrosion. Accelerated corrosion of a metal resulting from damage to a passive film by the turbulent flow of fluids is known as erosion-corrosion or impingement corrosion. Impingement and erosion-corrosion are apparently different degrees of the same basic phenomena — the eroding action of a fluid at high velocity. This includes cavitation and impingement attack caused by the formation and collapse of gas bubbles in regions of fluid turbulence and localized pressure fluctuations. It should not be confused with abrasion which is mechanical damage to a metal surface by solids or solids suspended in a fluid.

Impingement corrosion is generally associated with turbulent flow; erosion attack is often associated with the abrasive action of liquids or gases.

Fig. 6 is an example of impingement corrosion. The formation of eddies in the fluid at the entrance end of a heat exchanger tube damages the passive metal film. Channels are formed in the tube wall exposing fresh metal which is repeatedly attacked until perforation occurs. This type of corrosion can occur in any equipment where fluid is forced to enter or leave through a small restricted opening.

Fig. 7 illustrates erosion-corrosion due to the flow of fluid through a pipeline under high pressure or velocity. The eddies produced at the pipe surface remove portions of the protective film exposing new metal to attack.

Erosion-corrosion under these circumstances may occur over the entire pipe or tube length to produce a directional type of pitting action. Sometimes the presence of solids suspended in the fluid contribute to failure of equipment by erosion-corrosion.

Concentration Cell Corrosion

Attack of metals may occur between gaskets and flange faces, lapped joints, nuts and washers, under protective coatings, or at any point where a crevice or stagnation pocket exists. This attack is best described as the formation of a galvanic cell. A difference in oxygen concentration may cause the area within the crevice to become anodic or active. This type of corrosion is sometimes called crevice or contact corrosion.

One of the most important examples of concentration cell corrosion is that caused by variations in dissolved oxygen. Such cells are most apt to be encountered where oxygen depolarization is the major factor controlling corrosion. Fig. 8 illustrates a flanged joint in an austenitic stainless steel pipeline. The crevice produced by improper gasket fit is ideal for formation of oxygen concentration cells.

A large part of the oxygen present in the stagnant fluid is consumed during initial corrosion and cannot be replenished readily, while fluid flowing past the crevice furnishes a continual supply of oxygen for depolarization of the cathode areas. Since stainless steels rely upon a passive oxide film for corrosion resistance, there is no possibility of the anodic areas passivating themselves once the corrosion process has been initiated. Also, since the anodic area is very small with respect to the cathode area, the corrosion process will be very rapid.

Fig. 9 shows a porous deposit of corrosion products formed on a carbon steel pipe. This is sometimes referred to as tuberculation. The area under the scale is low in oxygen and unable to form a passive film. Fluid moving slowly past the deposit is relatively high in oxygen which aids depolarization of cathode areas surrounding the deposit.

Fretting Corrosion

Rapid deterioration at the interface of metals when they are clamped, press fitted or shrunk fitted together under high pressure, and subject to small vibratory motion is known as "fretting corrosion." Fretting corrosion is particularly damaging to bolted joints and machine parts of mechanical equipment. The mechanism of attack is not completely understood and there is considerable disagreement among investigators as to its cause. Suffice it to say that small metal particles torn from the metal surfaces by small relative movements are oxidized by the surrounding atmosphere. With carbon steel, this results in a reddish brown oxide being found at the metal interface, particularly near the ends of fitted assemblies. This brown oxide is sometimes referred to as "cocoa" and the process of corrosion as "friction-oxidation."

Unlike many other forms of corrosion where the products of corrosion often serve as protective coatings against further attack, the slipping movement at the contacting faces destroys the continuity of protective films in fretting corrosion. Under this condition corrosion can proceed at a rapid rate and to relatively great depths.

Prevention of fretting corrosion relies upon elimination of small relative movements between faying surfaces of joined parts, and the application of protective lubricants and weatherproofing compounds. Thus, to overcome fretting corrosion it is necessary to increase the interface loading enough to prevent motion of the surfaces. It is sometimes possible to increase joint friction by roughening the surfaces enough to stop slipping and consequent corrosion. And when the joint is properly protected with lubricant or weatherproofing compound, sufficient to keep out air, metals and combinations of metals have reduced rates of fretting corrosion.

Hydrogen Blistering

Hydrogen blistering is indirectly caused by nascent hydrogen which is released during the corrosion of steels by acid compounds such as hydrofluoric acid, sulfuric acid, or hydrogen sulfide.

The atoms of nascent hydrogen combine to form molecular hydrogen which can dissolve in the solution or be carried off by entrainment. Some of the nascent or atomic hydrogen will penetrate and diffuse through the corroded steel surface.

If this nascent hydrogen locates a crevice, discontinuity, slag inclusion or break in the steel it will collect in such a location, forming molecular hydrogen with other hydrogen atoms. As the amount of molecular hydrogen increases, the pressure of the trapped hydrogen will also increase. The pressure will increase until the metal fractures usually in the form of a cracked blister. Pressures as high as 2700 psi have been measured inside of the blisters.

In the petroleum industry some crude tanks, some gasoline storage tanks and other equipment usually containing small amounts of hydrogen sulfide are subject to hydrogen blistering.

Control of Hydrogen Blistering

The most effective way to prevent hydrogen blistering is to prevent the corrosion which produces the nascent hydrogen. This can be accomplished by:

1. Applying concrete, gunite or plastic linings to carbon steel plate construction;
2. Using suitable stainless steels which would withstand corrosion from the acidic compounds;
3. Neutralizing the acids or removing the acid constituents;
4. Control the quality of carbon steel plate, thus reducing the number of inclusions, breaks, laminations, dirt blisters or scale formations rolled into the carbon steel. ★ ★ ★

CORROSION REPORT

Corrosion in Amine Type Gas Processing Units

No one answer to this problem . . . but here are some helpful recommendations

R. A. Graff
Graff Engineering Corporation
Dallas, Texas

WIDESPREAD USE of the amine gas treating process for removal of hydrogen sulfide and carbon dioxide from gas streams has resulted in several hundred plant installations, mostly in the natural and refinery gas processing fields. The amine process involves the absorption of acid gas components from a gas stream with a 15 to 30 percent water solution of MEA (Monoethanolamine), at ambient temperatures and elevated pressures. The solution is regenerated by boiling at reduced pressures and at temperatures between 220 and 280 deg F. The ordinary material for plant construction is mild steel; however, this has not proved to be satisfactory in all cases.

Alkalinity Variations

Alkalinity of amine solutions varies with temperature. Monoethanolamine solution is strongly alkaline at room temperature (pH $>$ 12 for a 10 percent solution), but at approximately 280 deg F, it approaches a neutral condition (pH estimated at between 8 and 9). The pH of a 15 percent MEA solution at 75 deg F and containing 4 std cu ft of CO_2 per gal of solution is 9.5. Accordingly, when heated to its boiling point under pressure, the solution's pH changes to the acid side. Also, a portion of the chemically combined carbon dioxide is liberated.

This combination of acid gas liberation and a slightly acid medium results in a condition that is corrosive toward carbon steel, and in general, occurs at the warmer portion of the operating cycle.

Vulnerable Equipment

The hot MEA solution heat exchanger unit, solution stripper and solution reboiler are most susceptible to attack and plants utilizing the highest degree of acid gas absorption in the enriched MEA solution usually experience the most serious corrosion difficulties. Corrosion rates are highest at points of extreme turbulence or high metal stress.

Control of acid type corrosion requires limited acid gas loading of the solution, with respect to solution concentration, and minimum regeneration temperatures, plus selection of proper construction materials for critical process equipment.

Effect of Impurities

An additional type of MEA solution corrosion occurs when impurities are present in the MEA solution. These impurities are produced by partial oxidation or thermal decomposition of the solution. If oxygen is present in the gas stream or if the solution is exposed to air in open equipment, MEA solution can be partially oxidized to aminoacetic acid and other complex organic acids. Partially oxidized MEA solution in the presence of CO_2 will absorb iron as a cold solution, and precipitate it as the carbonate, when heated. This results in an iron transfer system that can produce severe corrosion.

Where solution contamination is a result of exposure to air, blanketing the MEA storage or surge vessel with hydrocarbon gas often eliminates this problem. Excessive heating of MEA solution in the presence of CO_2 can also produce amine reaction and degradation products corrosive toward iron. This can be minimized by a side stream amine repurification process, such as redistillation or ion exchange.

Stress corrosion has been noted in MEA systems in both the cold and warm portions of equipment, particularly where hydrogen is present in the gas stream. This corrosion can be controlled by proper heat treatment of fabricated vessels and piping. Stress corrosion has also been found in conventional natural gas processing units where a high concentration of MEA is used or inadequate solution cooling facilities are available. Points where the highest degree of alkalinity and temperature occur are most susceptible to stress corrosion. A frequent example of stress corrosion is noted at welds in the hot, lean MEA solution piping from the base of the stripper to the MEA heat exchangers. In the absence of heat treating facilities, using an 18-8 type welding electrode to make the weld produces a satisfactory joint.

Erosion Problems

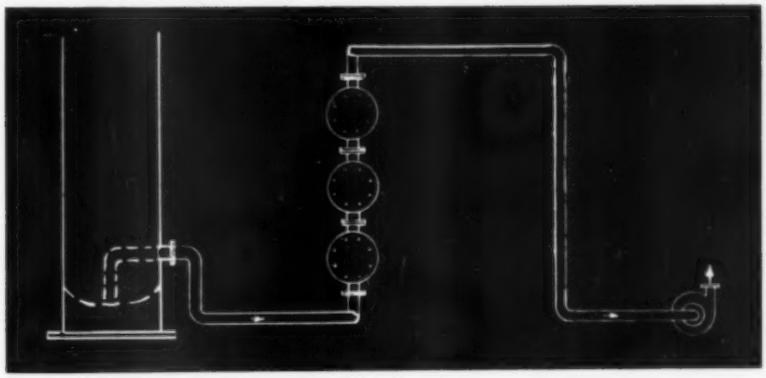
In some cases, at points of high solution turbulence such as at the discharge of centrifugal solution pumps and solution pressure let-down valves, a combination of erosion and corrosion takes place. Using hard facing alloy materials deposited on stainless steel will control this. High-pressure solution let-down valves of the angle pattern with extended venturi outlet type body have been found to offer a reasonable service life; however, all inner parts should be Stellited and seal welded to the body. Valve life can be increased by using larger line size valve bodies, with reduced port inner valves. Continuous filtration of MEA solution, to remove abrasive microscopic particles of corrosion products present in the solution, also increases valve life.

Answers to Turbulence

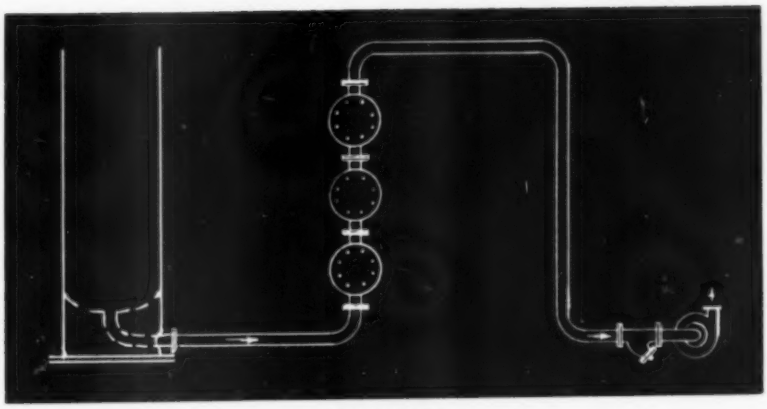
Hot solution piping, utilizing long sweep pipe bends fabricated from extra heavy seamless steel pipe. This eliminates zones of turbulence that frequently produce severe metal loss at the outer radius of weld fittings. In general, special care should be taken to avoid high velocities in solution piping, especially at points of solution entry into vessels, reboilers, exchangers, etc. (See Fig. 1.)

Reboiler Tube Problems

Solution reboiler tube corrosion can be one of the most serious initial operating problems encountered in gas purification units operating at high

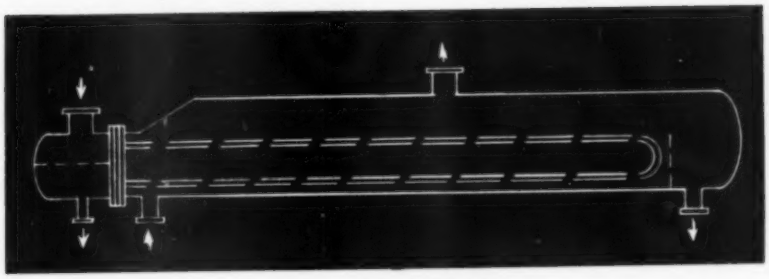


CONVENTIONAL

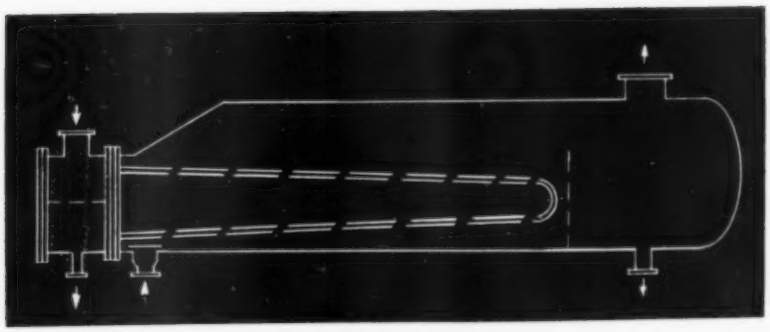


PREFERRED

MEA solution piping at base of stripper.



NOT RECOMMENDED



RECOMMENDED

MEA solution reboiler construction.

acid gas solution loading. Plants operating with a high temperature heating medium, using high heat transfer coefficients, experience the combined effect of erosion and corrosion. Effects can be extremely rapid in action. Similarly, when superheated steam is used for reboiling MEA solution, a definite corrosion pattern appears on the outside tube surface, adjacent to the steam inlet to the bundle, and in the desuperheat zone. Desuperheating the steam, prior to use, will eliminate this problem.

It is the general feeling that MEA solution reboilers should be designed to provide a liberal amount of vapor disengaging space between tubes, and with sufficient surface to produce a "simmering" action rather than violent boiling. The use of alloy tubes in MEA reboilers has produced erratic results. In some cases, carbon steel has proved equal to 18-8 alloy steels in corrosion resistance. "U" tubes are usually utilized for MEA reboiler service, and their length should be limited to prevent condensate "logging" and water hammer. This water hammer effect can produce severe tube vibration, and grooving of the tubes at the support baffles. Sloping of the tubes to facilitate drainage is also helpful in controlling this problem. (See Fig. 2.)

In addition to general reboiler tube corrosion and pitting, a localized corrosion due to alternate wetting and drying of tubes on the solution side often occurs. This sometimes occurs on top of the bundle, near the vapor outlet, resulting in pitting at that point. Enlargement or relocation of the vapor outlet at a point where it is not above a bank of tubes will correct this. In some instances, increasing the submergence of the tube bundle, by increasing the weir height, is desirable.

Heat Exchanger Corrosion

Solution heat exchanger corrosion problems occur, for the most part, where acid gases are liberated and, to a greater extent, at the hot unit of the exchanger battery. It has been recommended that absorber pressure be maintained at this point, in order to minimize flashing of acid gases. This tends to reduce the turbulent action of the rich MEA solution in the heat exchanger. As an alternate procedure a flash drum, located directly downstream from the absorber liquid level control valve, will eliminate a large portion of flashed vapors.

Exchanger Construction

The use of two pass, shell side, solution heat exchanger construction should be avoided, since localized shell corrosion usually occurs at the "dead" zone where the transverse shell baffle contacts the shell. In general, the solu-

tion exchanger should be designed for one or more passes on the tube side, and single pass on the shell side. Stainless steel impingement baffles at snell entry nozzles should be installed to minimize tube erosion and corrosion. These baffles should not be of the perforated type.

Corrosion at the solution stripper is not initially a serious problem, due to the low liquid velocity in the vessels, and the protective nature of the mill scale attached to the steel. Under conditions where the vessel is operated in CO_2 service and at a temperature of above approximately 250 deg F, the base metal is exposed after 12 to 18 months' operation, and the corrosion rate then increases very rapidly. For this reason, a stainless clad or 100 percent stainless steel vessel is recommended for strippers operating at elevated pressure. Usually, vessel internals utilized for this operating condition also are fabricated of stainless steel; however, Porcelain Raschig Rings are used, rather than stainless steel bubble trays. Results from the use of plastic or cement linings have been rather disappointing due to lack of adherence. In the case of cement linings, the leaching of silica from the cement by the MEA solution has been a major problem.

Alternate Agent

Diethanolamine solution is used sometimes in refinery applications, due to its low reactivity toward oxygenated sulfur compounds. However, when contaminated, this material is extremely difficult to repurify, and is being replaced gradually by MEA whenever process conditions permit.

Inhibitors

The search for a usable corrosion inhibitor for MEA solutions has created a situation among chemists almost parallel to the ancient alchemists' search for the "philosopher's stone," said to change base metals into gold. (The same could be said for suitable solution filter elements.) To date, numerous organic and inorganic compounds of arsenic, chromium, copper, phosphorus, sulfur, and other obvious materials have been tested with negative results. Maintaining a high pH in the system still seems to offer the most promise for protection. One operator reportedly carries a high percentage of potassium carbonate in the solution, in addition to the usual concentration of 15 percent MEA, and has noted a considerable decrease in corrosion rate, which he attributes to increased solution alkalinity.

Recommended Materials

Relative to materials of construction for critical portions of gas treating units, there is no common alloy, or corrosion inhibitor, that can be generally recommended. There is no rigid pattern for selection of materials of construction for amine type gas treating units. Listed below are a few of the various metals and alloys that have been found satisfactory:

ABSORBERS

ASTM A-283, A-285, A-212 and other low carbon content steels. Except where weight limitations exist, there is usually no advantage to use of chromium-nickel or other alloys.

STRIPPERS

ASTM A-283, A-285,A-212 and other low carbon content steels. Type 304 and type 316 stainless solid or clad vessels are recommended where CO_2 is present, and the solution is regenerated at a temperature above 250 F.

Aluminum, 3S, has been used in systems employing Diethylene glycol-MEA mixtures. Alloys containing copper should be avoided.

REBOILERS

Recommended shell construction is identical as for Strippers. In the presence of H_2S, ASTM A-179-55T, seamless or welded steel tubes constitute the minimum requirement. 4-6 chrome alloys do not offer an appreciably longer life; however, 18-8 alloys such as type 304 will often give many years satisfactory service, where frequent failures occur with steel tubing. Alloys containing copper should be avoided.

In the absence of H_2S, 80-20 Cupro nickel alloy tubes have been found satisfactory.

Aluminum 3S tubes have been satisfactorily used where amine-glycol solutions are employed.

SOLUTION EXCHANGERS

Recommended shell construction is identical as for reboilers.

Tube construction is the same as for reboilers, except that many operators prefer to use a battery of three heat exchanger units, using alloy tube materials in the hot exchanger only, with the remaining two units using steel tubes.

SOLUTION COOLER

Shell side: ASTM A-283, A-285 or A-212 or equivalent.

Tube Construction: ASTM A-179-55T seamless or welded steel is usually satisfactory for conditions involving both H_2S and CO_2 bearing solutions. Control of corrosion on the water side may be attained through the use of bimetallic tubing. Where H_2S is absent, 80-20 Cupro nickel has been satisfactorily used as the tube material.

ACID GAS COOLER

Shell side: Identical as for solution cooler.

Tube construction: Identical as for Solution Cooler. Where low concentrations of MEA are used (i.e. 15 percent), and in the absence of H_2S in the solution, high purity copper tubing has been successfully used as protection against corrosion from both sides. When copper tubes are used, a liquid entrainment separator must be installed in the vapor line entering the acid gas cooler. The MEA plant solution will take on a blue color, indicating the presence of traces of ammonia-copper complex in the solution; however, the rate of corrosion for the copper tubes under this condition is very low.

SOLUTION PUMPS

Cast iron case and iron impellers for low-pressure service (i.e. 125 to 250 psig), although type 316 impellers are preferred.

Cast steel case and stainless steel trim is recommended for high-pressure operation. Multistage pumps should be charged with slow speed booster pumps.

REFLUX PUMPS

Same as for low-pressure solution pump service.

MOTOR VALVES

Iron or steel valve bodies with type 316 stainless inner valves are recommended for this service, and should be Stellite faced under conditions where pressure drop is above 100 to 200 psi.

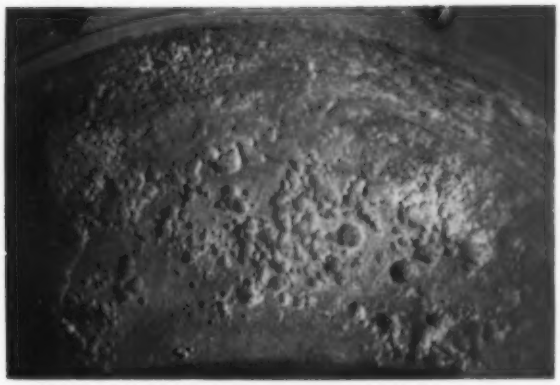
Although providing a harder facing, Carbaloy does not seem to offer the corrosion resistance of Stellite facing, and on the same basis, precipitation hardened, type 400 series stainless steels should be avoided for use as plugs and seats for high-pressure drop conditions.

In summation, corrosion of amine plants can be minimized with the following design considerations:

- Moderate acid gas loading of the solution.
- Minimum operating speeds for pumps.
- Low operating temperature for the solution strippers.
- Low velocities in solution and vapor transfer lines.
- Oversized reboilers.
- Elimination of points of turbulence from the solution flow system.
- Elimination of all solids as well as oxygen from the solution system.

In many cases, these considerations can more than double the minimum plant investment cost as well as increase utility requirements. ★ ★ ★

Try Zinc Anodes for Heat Exchanger Protection



Head after three years without anodes.

William T. Lawler
Sun Oil Company
Dallas, Texas

Head after one year without anodes.

WATER COOLED heat exchangers receive corrosion protection from zinc anodes. This has been successful in all hydrocarbon processing plants operated by the Southwest Division Natural Gas Department of Sun Oil Company. With knowledge of the extensive use of zinc anodes in sea water service, a test program was set up four years ago to determine the effectiveness of zinc anodes when used in plant cooling water systems having undergone three to five cycles of concentration at different treat conditions. All cases have shown excellent results. Improved heat transfer efficiency and lower maintenance costs are indicated.

The problem. Corrosion in cooling water systems was found most frequently in lines and equipment operating at low water velocities. These low velocity conditions permitted the deposition of organic matter and products of corrosion. Pitting action occurred if these deposits were allowed to remain for several months before cleaning.

This type of metal loss was most serious in the channel and floating head ends of exchangers. Tubes in exchangers in service more than two years without attention were found plugged so badly that heat transfer was seriously reduced. Severe metal loss of gasket surfaces has occurred in some exchangers. Heads in this condition had to be replaced or sent to a metal shop for metal build-up.

Good results on first test. After the first successful test results were obtained, it was decided to install zinc anodes in the channel and floating head ends of each exchanger. This was done while the exchanger was out of service for routine preventative maintenance inspection. This resulted in the cost of anode installation having a material to labor ratio of 1.0.

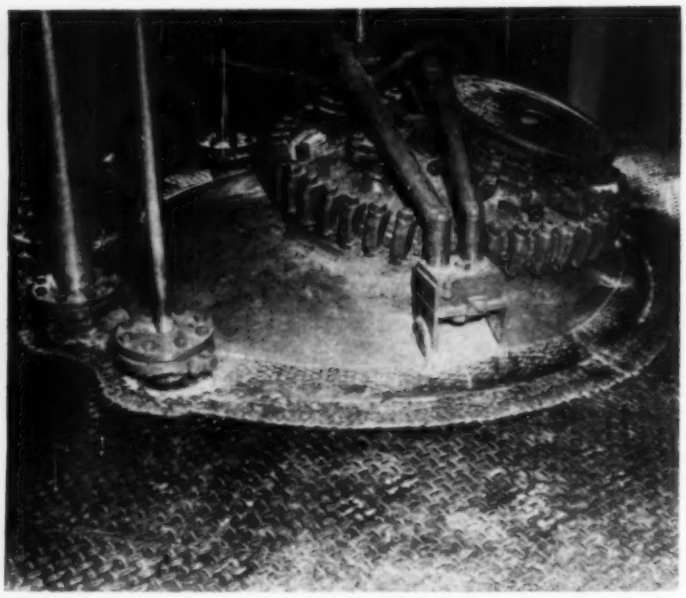
Anode installation is relatively simple. A clamp secured by a stud in a tapped hole holds the anode in place. **Anode size and location is determined by the size and design of the heat exchanger with care taken not to restrict the flow of water.** For this purpose 2-in. by 2-in. zinc bars with iron cores are cut to convenient lengths. The surface to which the anode is to be attached is cleaned to bright metal immediately before installation.

Anode size. No attempt was made to calculate the anode size nor to regulate the current output. The driving potential of zinc in cooling waters tested is at a level where rapid anode deterioration is not experienced. Anode installation life normally exceeds two years. Zinc bar is a stock item and can be obtained from most cathodic protection supply companies. ★ ★ ★

Head after one year with anodes.

Channel after 1 year with anodes.

Plastic sheet protects this vent stack.



Spillage to lower levels is prevented by the plastic sheet around this reactor.

Good customers for their own products . . .

How Petrochemical Plants Use Plastics to Fight Corrosion

Donald R. Gray
The Dow Chemical Company, Midland, Michigan

PLASTICS for corrosion protection are relatively new engineering materials. Use has grown rapidly . . . often ahead of the handbooks. While no cure-all, plastics promise improved housekeeping and extended service in many areas of petrochemical and refining operations.

Literally hundreds of applications can be counted. Five areas of application are scouted here to demonstrate the range and reason.

Piping

Plastic pipe is gaining wide acceptance in petrochemical plants. Pipes and fittings produced from polyvinyl chloride, cellulose acetate butyrate, polyethylene, glass-reinforced epoxy and polyester, and Saran all enter the picture. But, education and design problems accompany this evolution.

Thousands of feet of plastic pipe are used in our own plants. We have found that successful application calls for full cooperation . . . not only by the design engineer and pipe manufacturer, but by the pipefitter and the plant operator.

Polyethylene pipe . . . it can be cut with a knife . . . is being used in large quantities with fittings that are relatively simple and reliable. In some areas, cellulose acetate butyrate finds use in small gas lines and as brine disposal pipe in oil fields.

Polyvinyl chloride pipe . . . PVC . . . is receiving much use in applications requiring high chemical resistance. The United States is still catching up with a fast pace set abroad. An English atomic energy plant has used large PVC ducts for hydrochloric acid fumes. Transparent rigid PVC forms a portion of the duct work, so that the contents can be viewed.

Inert plastics to line metal pipe and fittings is another practical engineering approach. Polyvinylidene chloride copolymer resin (Saran) has long been established in this area, in pipe, valves, fittings, and pumps up to eight inches diameter. This lined piping can be easily adapted to join other corrosion-resistant piping or to standard steel pipe. Temperature-use range is from well below zero up to 200 F. The material is resistant to practically all inorganic chemicals and to most organic solvents and compounds.

Plastic joints in sewer tile are another example of the combined use of plastics and conventional material. In addition, underground piping often demands protection from corrosive soils. A pipe wrapping of Saran or polyethylene film and a protective kraft paper has provided one answer.

A six-year exposure test of sections of polyvinylidene chloride film used as a pipe coating has demonstrated durability. The underground pipeline oper-

ated at 120 F, with no significant changes in tensile properties, dielectric strength or water vapor permeation rate.

In such applications the film is usually wrapped over a hot coat of microcrystalline wax. Complete inertness to all hydrocarbons is of special note. Another use involved a water header. Wrapped with glass cloth and polyester resin, curing provided a hard and corrosion-resistant surface.

Flashings

Flashing applications of a flexible vinylidene chloride copolymer are of interest. In sheet form, this thermoplastic is pliable, conforms to irregular shapes, elastic, and easily adhered to other materials and itself. Uses are basic: Flashing of corrugated roofs to masonry walls and flashing of pipes and conduits entering buildings.

Flashing around reactor kettles and other equipment is a less usual but effective use. Spilled chemicals are kept from finding their way to lower levels. As illustrated, the plastic sheet is cemented to the vessel and to the floor.

Answers are provided to more complicated flashing problems, too, such as protecting the base of a column where it extends through the roof to support a superstructure. A permanent water seal and expansion joint is achieved under the most adverse chemically corrosive conditions.

Coverings and Coatings

A broad and developing area is the use of protective coatings based on plastics materials. Sturdy finishes for laboratory equipment, for plant buildings and for process equipment are made possible.

In a chemical process building which makes extensive use of polyvinyl chloride pipe, the manufacturer used urethane-based paint on the structural steel. The paint provided the same order of resistance as the pipe.

An oil company has found use of silicone-based paints on a catalytic cracker valuable not only from the standpoint of durability at high temperatures but also of color retention.

Problems of chemical corrosion may call for special building furnishings or interior finishes. A typical laboratory office, for instance, may have melamine walls, vinyl-clad furniture and desks, reinforced polyester doors, and be lighted through a rigid vinyl ceiling.

In areas of severe corrosion where ceramic tile floor is desirable, a new epoxy grout provides superior strength, chemical resistance, and cleanability. Epoxy cements also could be used to bond large panels of ceramic tile up to four by six feet for faster installation.

Laboratory sinks and counter tops may be lined with a flexible plastic sheet, which also helps to reduce glass breakage.

Leaching can be a serious problem on exterior masonry surfaces of plant buildings. A silicone water-repellant paint has been applied successfully to stop efflorescence. Sprayed vinyl coatings have been used in corrosive atmospheres for greater life and easy cleanability of equipment.

Light Transmission

Several types of plastics materials are providing transparent and translucent lighting panels. Some examples: Polyvinyl chloride in quarter-inch translucent sheet as a vertical skylight. Corrugated glass reinforced polyester panels on vertical walls, and in sheet form as industrial skylights. Vacuum-formed dome lights, made from translucent acrylic material, provide permanent light transmission to spot roof areas.

Linings

In addition to piping uses of Saran, flexible Saran sheeting as linings for process equipment has been particularly successful in solving corrosion problems in our own plant operations.

Lining of a tank trailer, for instance, has protected the steel tank for more than four years. The trailer hauls hydrochloric acid and ferric chloride. In another case, the plastic sheet lining is used in a vacuum deaerator where demineralized water is handled in power plants for boiler feed water. It protects the steel from extreme corrosive action and prevents contamination of the water with metal ions.

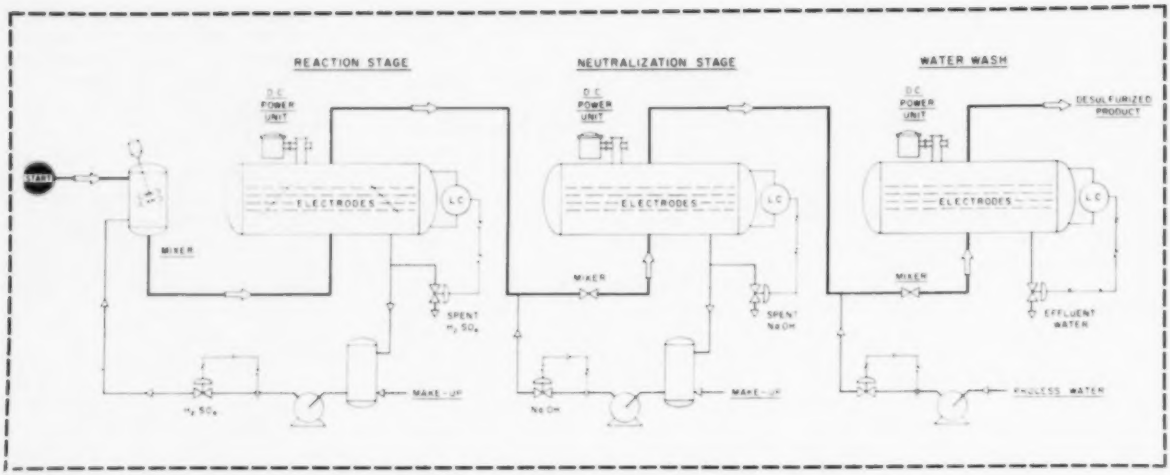
Linear polyethylene is finding service in the construction of tanks and as tank lining. Special grades of polyethylene with high stress corrosion resistance are available. A British plant reports use of polyethylene tanks 15 by 8 ft by 5 ft with satisfactory performance since 1951. They are made of ¼ in. sheet to hold acid effluent before neutralizing.

Repair of concrete tank surfaces which have given way to corrosion is possible with plastic coatings. One application . . . in a slurry settling tank . . . uses polyester resin in damaged areas. Alternate layers of glass cloth and polyester are applied. A final coat of resin completes the serviceable lining.

Another example is a concrete pump base, enveloped in Saran sheet with a contact adhesive. Lapped joints are made with a ketone solvent. The plastic sheet promises long protection of the concrete against the ravages of dilute acid and water.

Epoxy resin pump blocks have been installed at the company's Midland division for pumping highly corrosive iron bromide liquor. Initial cost is higher than that of soapstone pump blocks, but longer service life is expected from the epoxy because of its strength, durability and corrosion resistance. ★ ★ ★

"Who told you to abbreviate 'catalyst storehouse'?"



Process flow for the electrostatic desulfurization process.

NEW Desulfurization Process Onstream

The world's first electrostatic desulfurization unit has recently been placed in operation at Cities Service's East Chicago refinery. Here's the first published report on its operation . . .

Robert J. Phillips and H. G. Napier
Howe-Baker Engineers, Inc.
Tyler, Texas

THE FIRST COMMERCIAL electrostatic desulfurization plant was placed in service for Cities Service Oil Company at their East Chicago refinery during October 1958. Subsequent exhaustive testing has shown that the plant meets all process requirements, with the sulfur content of the treated product averaging less than 25 ppm. The unit is similarly effective in removing arsenic. The new process employs a technique described as "electrostatic mixing" to greatly enhance reaction efficiencies.

Process Flow

As shown in the flow diagram untreated hydrocarbon enters the processing system through a small mixer vessel. This vessel is equipped with specially-designed turbine-bladed mixers. Spent alkylation acid, averaging 90 percent in strength, is added directly to the mixer vessel. The acid-hydrocarbon solution is vigorously mixed, reducing the acid particle size to a pre-determined optimum diameter.

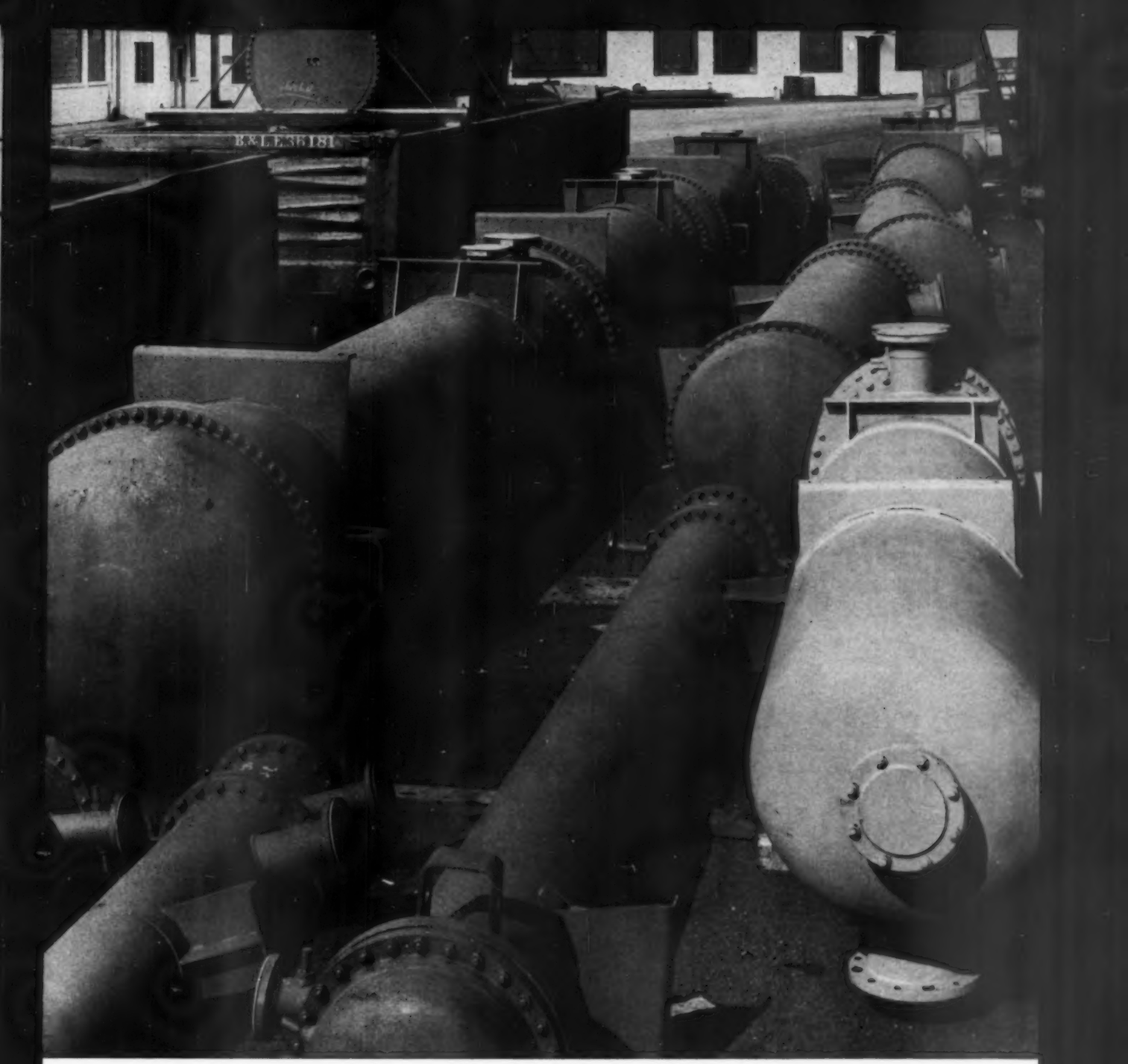
Hydrocarbon containing the acid dispersion then enters the bottom of the first electrical unit, referred to as the Reaction Stage. Here, the dispersion is subjected to sufficient electrostatic mixing to insure completion of the oxidation reaction of sulfur compounds to the disulfide form and subsequently moving the reaction products into the acid phase. In the center portion of the reaction stage, the partially spent acid containing the reacted disulfides is continuously coalesced, collected in the bottom of the vessel, and recirculated until spent.

Hydrocarbon from the reaction stage, containing from 20 to 75 ppm of suspended sulfuric acid, is vigorously mixed with sodium hydroxide solution of about 10 percent concentration. This mixture is separated by electrical coalescence in the second, or neutralization stage. Carry-over of suspended caustic from this section is normally zero, but during periods of major changes in operations was as much as 2 ppm.

The neutralized hydrocarbon is water washed and electrically coalesced in the third unit. Any traces of suspended water are removed in the mechanical drier that is the final unit in the processing scheme. The treated product then proceeds through a surge tank to the reforming unit.

Analysis of Operating Data

Pertinent operating data are summarized in Table 1. The Cities Service plant was designed to desulfurize 8000 BPSD of Mid-Continent naphtha which would then be reformed in a fixed bed unit employing platinum-type



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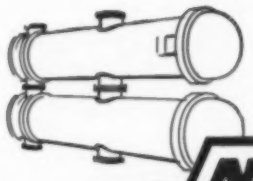

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catalyst. Although not a part of the performance specifications, it was expected that the concentration of trace metals such as arsenic and lead would also be substantially reduced. This has proved to be correct, with essentially complete removal of arsenic. No significant quantity of lead has been found in the feed stock.

Spent alkylation acid is employed since it is available to the refiner at no cost except for handling, and is completely satisfactory for the reaction. It was arbitrarily decided to recirculate the acid with the expectation that slightly better usage might be realized. It has developed, however, that recirculation is not necessary to obtain maximum acid utilization, and a once-through system would have been satisfactory.

Caustic consumption is higher than expected, due primarily to the necessity of neutralizing naturally-occurring organic acids, rather than any excess carry-over of sulfuric acid. Net caustic consumption of less than 0.15 lb of NaOH per bbl of hydrocarbon resulted in operating costs of less than 0.5 cents per bbl.

Operating labor requirements have been small, even during the startup period. It was found that the unit was "on-test" in about the time required for two displacements of the reaction stage. Further operating attention was not required. All flow rates are automatically controlled. Electrical energy requirements were fixed by the Howe-Baker startup engineers and have remained unchanged. Operating labor requirements are confined to occasional observation of liquid levels and the procurement of samples for routine testing.

About the authors . . .

Robert J. Phillips

Harris G. Napier

Robert J. Phillips, *inventor of the electrostatic desulfurization process, received his chemical engineering education at the University of Texas. After graduation in 1948, he joined Humble Oil's refinery technical service group. In 1952, Phillips became a member of Petroleum Refiner's editorial staff, subsequently holding the position of editorial director. In 1953, Howe-Baker hired Phillips to aid in the development of their electrostatic distillate treating processes. In 1957, he was promoted to the position of vice president with that company.*

Harris G. Napier *is chief operator for Howe-Baker. After graduating in chemical engineering from Texas Technological College in 1953, Napier joined Gulf Oil Corporation's technical staff at their Port Arthur refinery. He came with Howe-Baker in 1957 and initially assisted in the operation of their pilot plants. His promotion to his present position has resulted in traveling all over the free world supervising the installation and startup of Howe-Baker units. Napier was in charge of the startup of the Cities Service desulfurization and secured much of the test data used as the basis for this article.*

TABLE 1. Typical Operating Data.

Naphtha Charge, BPD	8000
Temperature, F	80
Reaction Stage	
Acid circulation rate, lb/bbl	12.5
Acid mixer speed, rpm	120
Electrode power consumption, KW	1
Temperature, F	82
Insoluble acid carry-over, vol %	0.002
Neutralization Stage	
Caustic circulation rate, BPD	400
Caustic mixing valve pressure drop, psi	8
Electrode power consumption, KW	1
Temperature, F	85
Suspended caustic carry-over, vol %	Nil-Trace
Water Wash	
Water injection rate, BPD	400
Water mixing valve pressure drop, psi	4
Electrode power consumption, KW	1
Temperature, F	81
Suspended caustic carry-over, vol %	Nil
Estimated Yield Loss, vol %	0.4

TABLE 2. Typical Stream Inspections.

	Naphtha	
	Charge	**Product**
Gravity, deg API	57.2	57.2
Distillation, F		
Initial Boiling Point	185	186
10%	230	230
50%	270	270
90%	325	323
End Point	363	364
Sulfur, ppm	300	22
Arsenic, ppb	5-17	0-4.0
Chlorides, ppm	2.0	1.0
Lead, ppb	0-9.0	0-3.0
Nitrogen (total), ppm	2.0	1.0
Nitrogen (basic), ppm	Nil	Nil
Sodium ion, ppm	Nil	Nil
	Acid	
	Fresh	**Spent**
Acid Strength, %	90.9	80.0

Typical Product Inspections

Average analyses of the treated product over long periods of operation of the Cities Service unit are shown in Table 2. Of paramount interest, of course, is the sulfur content of the treated product. The average of nearly 200 tests, performed by four laboratories working independently showed an average sulfur content of the treated product of 22 ppm or 0.0022 weight percent. A large number of results were reported as "0.0" and the highest result reported, regardless of the circumstances, was 43 ppm.

Analyses of the arsenic content of the feed showed a variation in concentration of 5 to 17 parts per billion. This was reduced in the treated product to 0 to 3 ppb.

Although there was very little lead in the feed stock (maximum was 9 ppb), analyses again indicated essentially complete removal to 0 to 3 ppb. (The authors doubt that analyses of any of the trace metals in the 0 to 5 ppb range have any real significance.)

Nitrogen compounds were curiously lacking in the feed stock. Both feed and product samples were analyzed by the different laboratories for both basic and total nitrogen. Tests indicated that no nitrogen was present. Previous work on samples rich in nitrogen confirmed that such compounds are more easily removed than sulfur. Yield losses were slightly less than 0.5 percent.

The remaining portion of this paper is devoted to an analysis of the effect of the operating variables, not only for the Cities Service unit but for other systems as well.

What Is Electrostatic Mixing?

Electrostatic mixing is a new chemical engineering technique or phenomena that employs electrical energy to accelerate the motion of an electrically conductive particle or ion

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within the body of a non-conductive medium. In the electrostatic desulfurization process, the conductive particle—sulfuric acid—is reduced by mechanical mixing to a very small (and optimum) particle size with a corresponding large increase in surface area. Electrical potential is applied to carefully oriented electrodes. The electrical energy thus transmitted to the system imparts a violent and rapid motion to the dispersed particles.

Effect of Feed Stock Composition

Virgin naphthas containing as much as 3000 ppm of sulfur have been successfully desulfurized. The only major effect on operating costs is a slightly higher consumption of acid. As the boiling range of the feed stock is widened into the middle distillate fractions, yield losses will increase since, of course, the molecular weight of the sulfur-bearing hydrocarbon has increased. Cracked stocks containing significant quantities of unsaturates may be successfully desulfurized, but greater yield losses would be expected. An electrostatic desulfurization plant for a visbreaker gasoline is under construction and nearing completion.

Effects of Time, Temperature, and Pressure

Pressure has no effect whatever on the completion of the oxidation reaction within the ranges conventionally employed of 25 to 200 psig. Elevated temperatures do little to improve the oxidation reaction, but can cause undesirable side reactions if allowed to exceed 140 to 150 F. For this reason, all electrostatic desulfurization plants are designed to operate at ambient temperatures. Reaction time is controlled to a total of from 12 to 16 minutes, depending on the nature of the feed stock.

Mechanical Mixing Is Important

External or mechanical mixing is employed solely to reduce the acid particle size to the optimum diameter necessary to achieve the desired mobility in the electrostatic field. The best acid utilization is dependent to a significant extent on achieving uniform particle size distribution. For these reasons, unusual care has been given to the design of the mechanical mixing equipment.

Acid Type Not Critical

The reaction may be successfully completed with initial acid strengths anywhere in the range of 88 to 98 percent. The Cities Service unit employs spent alkylation acid of approximately 90 percent concentration since it is available to them at little cost. Acid strength drops from 10 to 15 percentage points with usage. The net acid consumption or dosage will, of course, vary with composition of the feed stock. Acid dosages of five pounds per barrel of hydrocarbon are adequate for most reformer feed virgin naphthas with sulfur content of 400 to 800 ppm.

Caustic Strength and Consumption

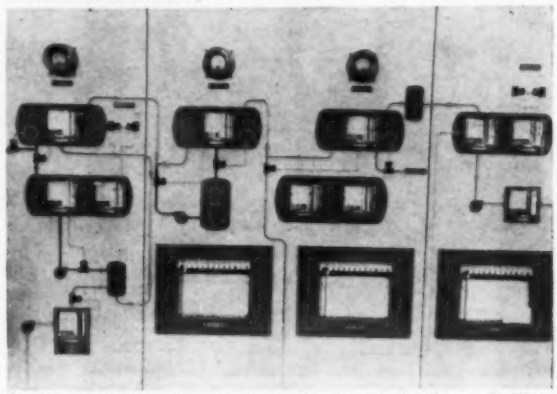
Caustic of almost any concentration may be used for the neutralization step. Designers usually will choose whatever strength is easily available in the refinery, but lower concentrations are preferred. The lower the strength, the greater the volume of caustic that can be used to provide a given amount of free sodium hydroxide, thus minimizing the contacting problem in the mixing section.

It makes little difference whether the caustic is charged on a once-through or recirculated basis. The only advantage for the recirculated system is that greater injection rates are permissible without sacrifice in net consumption. In any case, operating costs attributable to caustic consumption are not likely to be of sufficient magnitude to cause concern.

Is the Water Wash Necessary?

The water wash step has two functions: (1) Removal of any water-soluble reaction products present in trace quantities and, (2) Insurance against any operating upset upstream. It is difficult, if not impossible, to predict the frequency of upsets with any type of process unit. This process, however, is far less "sensitive" than most processes. To the authors' knowledge, no upsets of any sort have occurred in the Cities Service plant since it was placed in operation.

Electrostatic desulfurizer at Cities Service Oil Company's East Chicago refinery.



Control units for the electrostatic desulfurization unit illustrate the relative simplicity of the process.

What Are the Economics?

Since all engineering is reducible to dollars and cents, it is worthwhile to briefly review comparative economics. The installed cost of a 10,000 BPSD electrostatic desulfurization plant is about $350,000 as compared with about $1,000,000 for any conventional hydrodesulfurization unit of the same throughput.

Operating costs for the new process are from one-third to one-fourth of those for hydrodesulfurization. Desulfurization and metals-removal efficiency are the same or slightly less for electrostatic desulfurization. Delivery and construction time for the EDU design is less than one-half of that required for hydrodesulfurization.

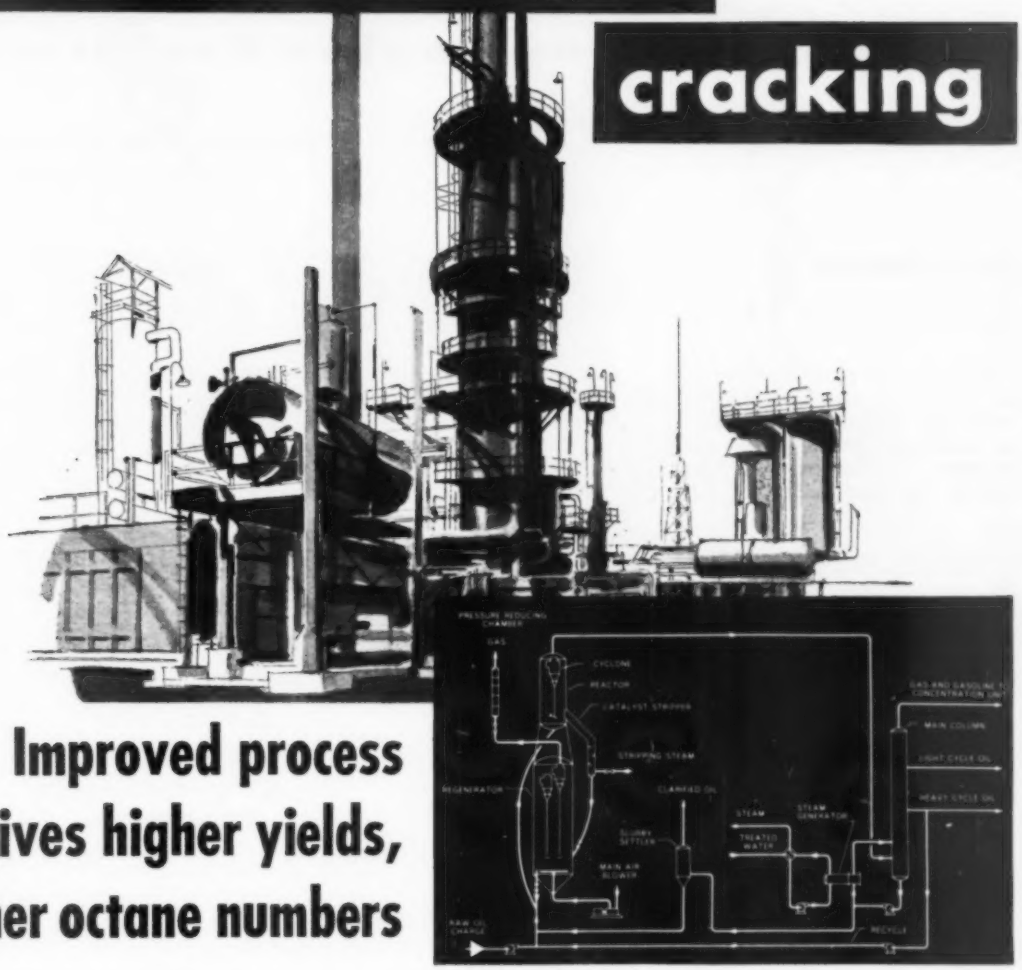
Status of Commercial Development

In addition to the recently completed Cities Service plant, units are now under construction for Imperial Chemical Industries and Commonwealth Oil Refining Company. Approximately 25 other plants are in one stage or another of engineering study.

Acknowledgment

The authors acknowledge with grateful appreciation the cooperation, assistance and encouragement of the Cities Service Oil Company — its management, engineering, operating and laboratory groups. Much credit is due Dr. Reid Robertson and his laboratory group of our parent company, National Aluminate Corporation, for their valuable assistance in performing the hundreds of necessary analyses.

UOP fluid catalytic cracking



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Gasoline Volatility
and its Effect on Engine Performance

Limitations on volatility can be foretold by the use of these nomographs

Geo. E. Mapstone
SATMAR,
Boksburg North,
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THE question of the influence of gasoline volatility on starting, warm-up, and vapor lock is one that has been studied by both the designers of engines and by petroleum technologists. Easy engine starting and rapid warm-up are provided by high gasoline volatility, but excessive volatility can cause vapor lock.

When volatility limits are set for the colder seasons, spring, winter and fall, starting and warm-up are prime factors; but the possibility of vapor lock must not be overlooked. Lower volatility limits of the gasoline must therefore be set that will assure satisfactory starting and warm-up at the lowest air temperatures expected, while the upper volatility limits must be set to protect against vapor lock at the highest temperatures to be expected.

In the hotter summer the main volatility problem is the question of vapor lock. This means that the RVP (Reid Vapor Pressure) and volatility must then be controlled by the probable maximum temperatures.

Domke, Tracy and Taliaferro[1] have

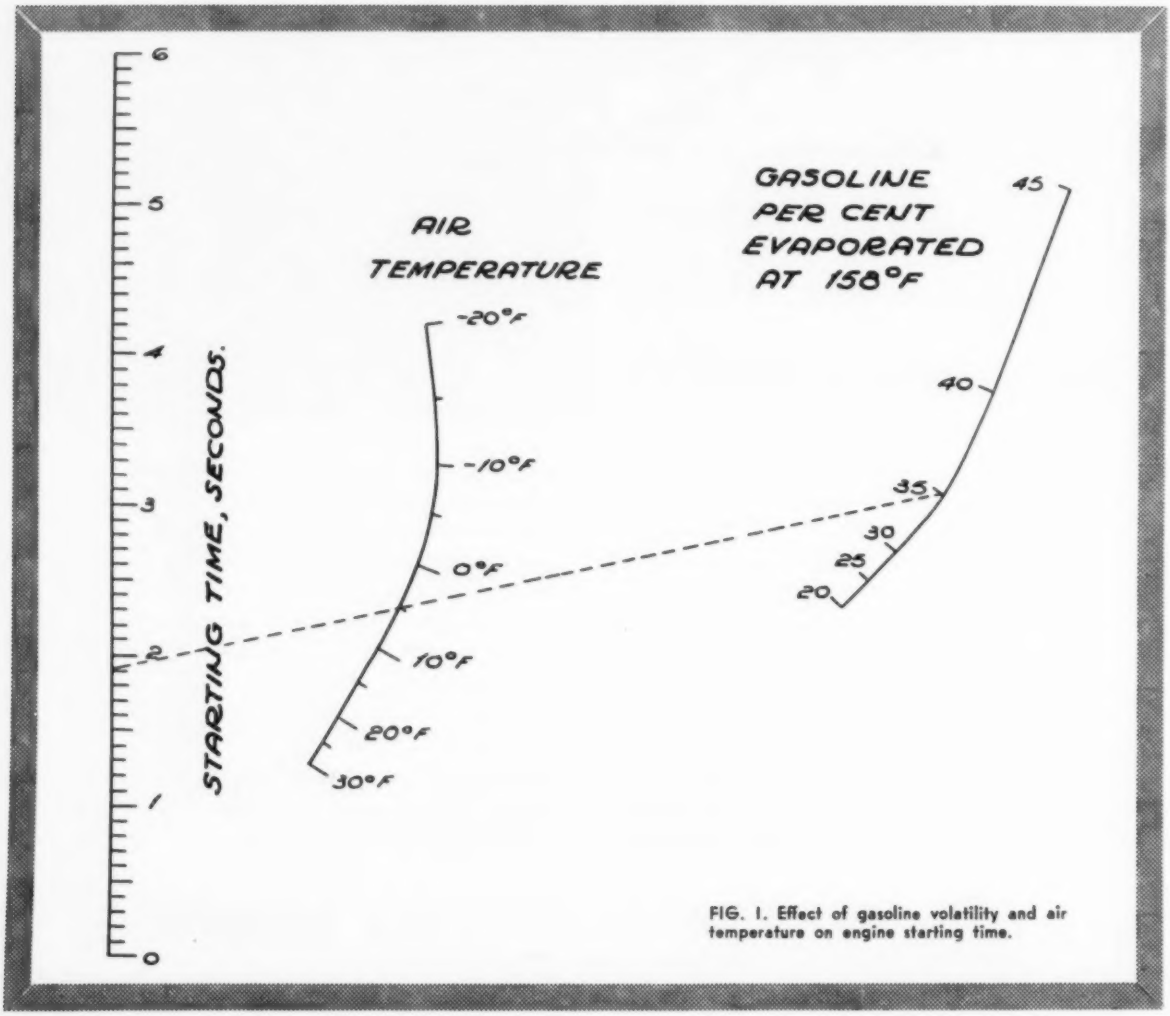

FIG. 1. Effect of gasoline volatility and air temperature on engine starting time.

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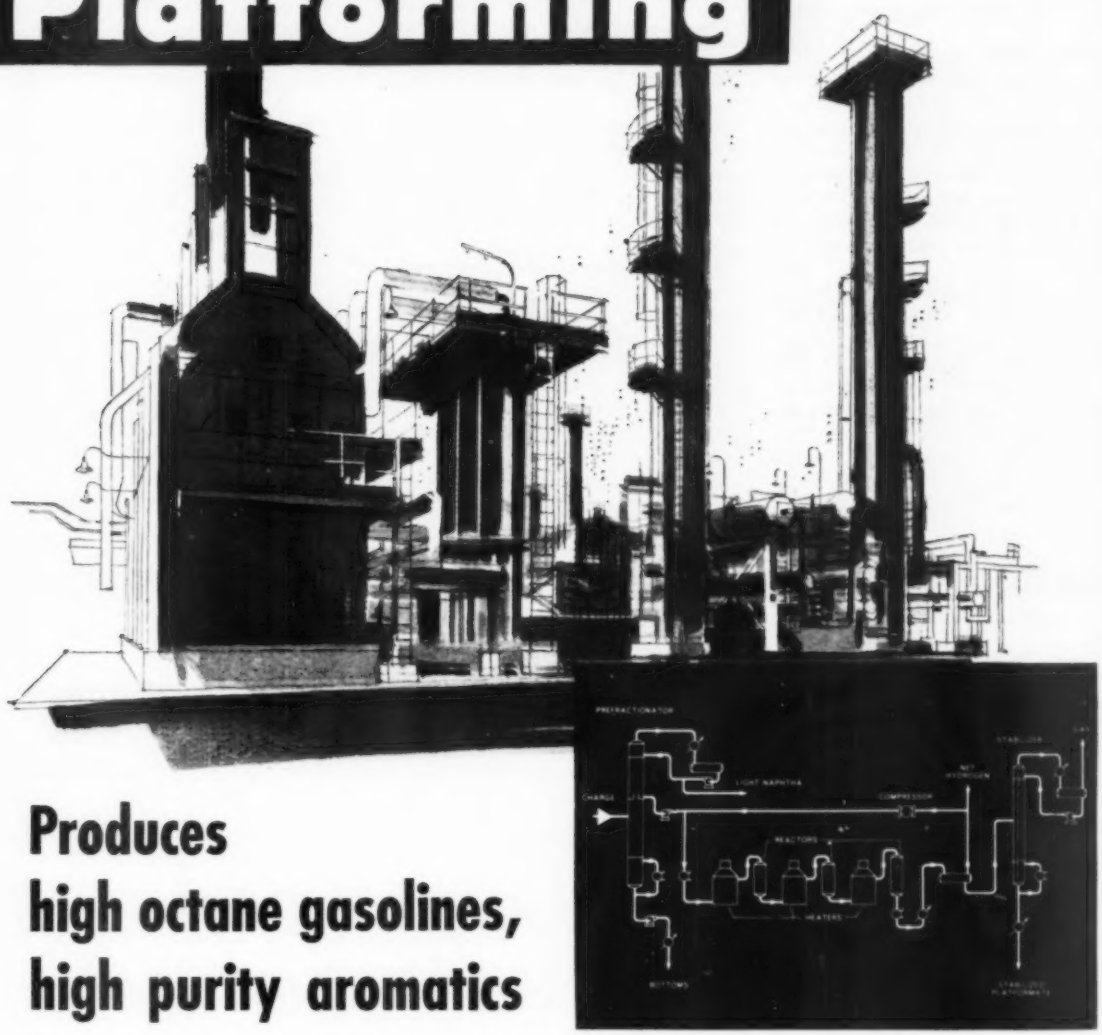

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Equally important, it enables the refiner to produce in commercial quantities excellent base stocks for aviation gasoline and Platformate for aromatic extraction such as benzene, toluene and xylenes, now in such growing demand for detergents, nylon, plastics, high explosives and many other products.

As shown in the accompanying flow diagram, the Platformer is a compact unit consisting of a reactor section, stabilizer section, and (optional) feed preparation section. It can handle the full boiling range gasolines without prefractionation, or naphtha cuts separated from them, and efficiently processes any naphtha from crude distillation, natural gasoline plants or cracking units.

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derived experimental relationships between the gasoline volatility and engine performance which are presented here in convenient nomographic form.

Starting Time

The starting time for a gasoline engine using the CRC Procedure F-6-943[2] can be calculated from the air temperature and the percent of the gasoline evaporated to 158 F. In this method the starting time is the number of seconds from the initial engagement of the starter until the engine fires for the first time.

The nomograph presented as Fig. 1 allows the ready application of the data, and its use may be illustrated by the following example:

If 35 percent of the gasoline evaporates at 158 F and the air temperature is 5 F, what is the starting time? Use a straight edge to connect 35 on the percent evaporated (right hand) scale and 5 on the temperature (middle) scale and extend to cut the starting time (left hand) scale at the required value of 1.9 seconds.

Warm-up Time

The engine warm-up time can be related to air temperature and the gasoline volatility as measured by the percent evaporated at 158 F and the temperature at which 50 percent had evaporated. The method of Taylor and Gibson[3] was used for determining the warm-up time which is defined as the number of minutes needed for satisfactory acceleration without the engine bucking or backfiring. Fig. 2 presents the data in convenient nomographic form, and its use is illustrated by means of the following example:

If 34 percent of the gasoline is evaporated at 158 F and 50 percent is evaporated at 210 F, what is the warm-up time when the air temperature is 30 F? Step 1. By means of a straight edge connect 34 on the percent at 158 F scale with 30 F on the air temperature scale and extend to cut the tie line. Step 2. Connect this point on the tie line with 210 F on the 50 percent evaporated scale and extend to cut the warm-up time scale at the required value of four minutes.

Vapor Lock Factors

The tendency for a gasoline to cause vapor lock troubles was related to the RVP and the percent evaporated at 158 F of the gasoline, and to the air temperature. The test procedure followed[1] consisted of a high speed stabilization run, a 15 minute soaking period and a high gear, full throttle acceleration to 70 mph. Uneven performance during the acceleration was rated as incipient vapor lock.

The vapor locking tendencies of all cars were found to be affected by the wind velocity; higher wind velocities resulted in a greater vapor pressure tol-

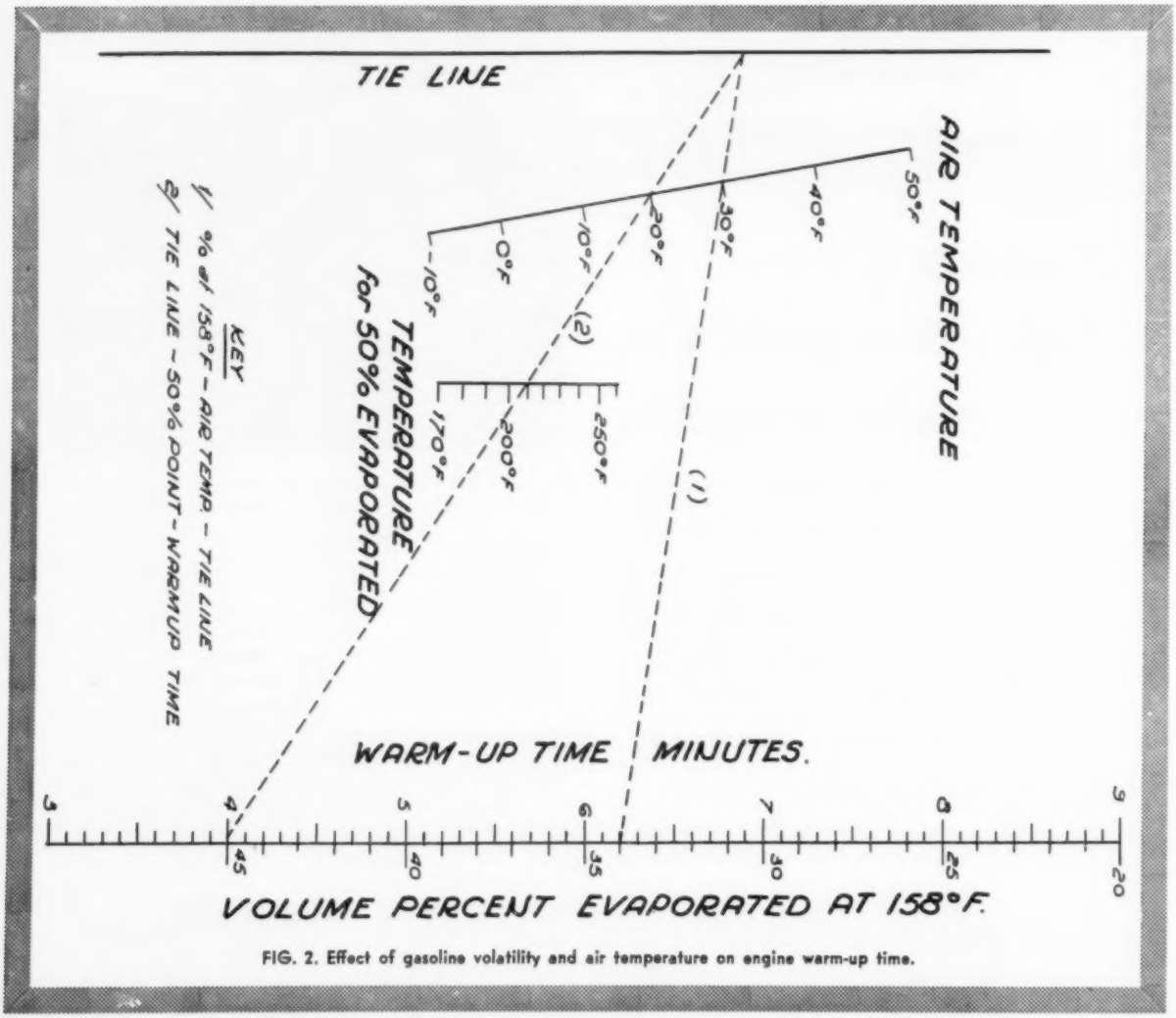

FIG. 2. Effect of gasoline volatility and air temperature on engine warm-up time.

California Bulk Acid Polymerization

Licensed by: California Research Corporation

DESCRIPTION: The feed stream is preheated and combined with a stream of circulating phosphoric acid. Thorough mixing is achieved as the acid hydrocarbon stream passes through a small, high-efficiency reactor. Separation takes place in a settler, and the acid is pumped through a cooler back to the reactor. No hydrocarbon recycle or other "quenching" arrangement is needed. The product stream is caustic-washed and then stabilized in a conventional recovery section. Feed must be essentially free of H_2S, mercaptans, and basic nitrogen compounds.

Temperature control in the reactor is excellent, because this is an all-liquid system and the recirculating acid stream has a high heat capacity.

Feed stocks and products are similar to those for fixed-bed polymerization plants.

This process has only recently been made available for licensing, and commercial experience is limited to a 100-BPD demonstration plant. Information on operating conditions, investment costs, etc., can be made available to parties interested in building a plant, but such information is not yet released for general publication.

SERVICE FACTOR:

High operating factor can be expected, because the plant is mechanically simple and because used acid catalyst can be replaced without shutting down.

UTILITIES:

(Based on plant consisting of water wash, reaction section, and stabilizer) — Normal operating requirements of steam and cooling water lower than for fixed-bed process, because there is no hydrocarbon recycle. Power requirement about the same as for fixed-bed, because acid pumping largely compensates for omission of hydrocarbon recycle pumping. This process eliminates need for regeneration utilities.

PHOSPHORIC ACID:

Catalyst life has been carried to a level of 45 gallons of polymer per pound of acid without any noticeable lowering of conversion or acid deterioration. Ultimate catalyst life should turn out to be appreciably higher than this, probably in the range of 100-200 gallons per pound as commonly reached in the fixed-bed process.

OPERATING PERSONNEL:

One man per shift.

INVESTMENT & MAINTENANCE:

Estimated investment costs are lower than for fixed-bed polymerization processes. Maintenance costs expected to be about the same as for fixed-bed.

California Film Acid Polymerization

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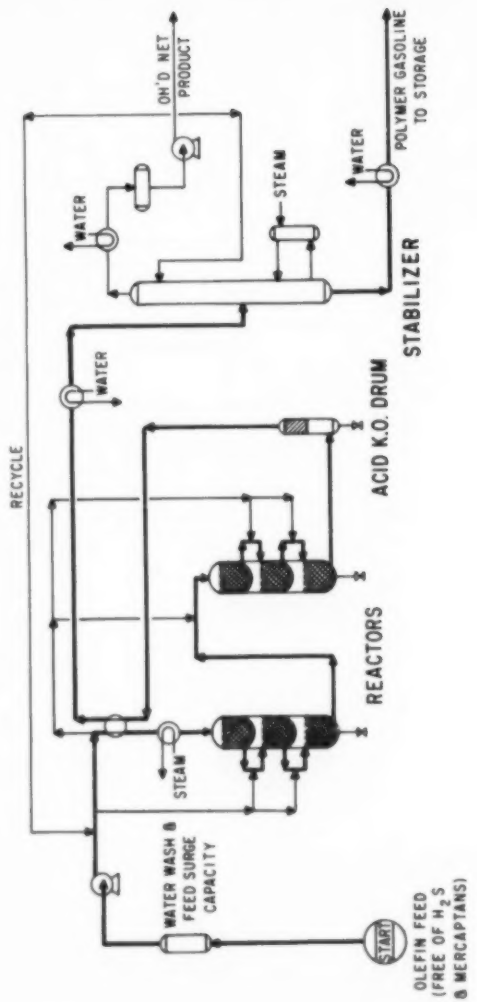

OPERATING CONDITIONS:

	°F	psig
Reactor Inlet	275-325	500
Reactor Outlet	375	450-480

California Film Acid Polymerization

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DESCRIPTION: The feedstock, an olefin-containing C_3 or C_3/C_4 cut, is treated to remove catalyst poisons, then fed as a vapor to the top of the first reactor. Stabilizer overhead liquid is recycled to control olefin concentration at an operable level and to help take up heat released by the highly exothermic reaction.

By use of cold liquid as quench, inlet temperature to each successive bed is regulated to hold maximum bed outlet to around 375 F.

Catalyst support is 28-35 mesh crushed quartz, or a comparably fine natural sand of high purity. Acid catalyst is applied by flooding the reactor, then draining off the excess to leave a thin acid film on the quartz particles.

Catalyst is regenerated by washing off spent acid with water, steaming, drying and then recoating with fresh acid. A quartz bed can normally be used through successive regenerations for well over a year.

PRODUCTS

Polymer gasoline consists principally of C_7/C_{10} olefins. Normally, about 90 percent of feed olefins are converted to polymer, but design can be made for higher or lower conversion to meet special needs. Typical properties of debutanized polymer are:

	Propene Polymer	C_3/C_4 Polymer
Gravity, °API	57.1	63.0
RVP, psi	0.8	2.6
Octane No.*		
F-1 Clear	93.0	96.0
F-1 + 3cc TEL	99.0	100.0
ASTM Distillation, °F		
IBP	180	130
10%	251	215
50%	305	252
90%	390	365
EP	453	440

*Octane blending values are substantially higher than these octane ratings of pure polymer given above.

SERVICE FACTOR: 95 percent

UTILITIES (For Typical Plant Charging 1,000 BPOD Fresh Feed)

Normal Operation

Steam	3,000 lb/hr at 110 psig
Power	40 KW
Water	250 GPM

Additional Requirements During Regeneration

Steam	7,000 lb/hr at 110 psig
Power	5 KW
Water	50 GPM

CHEMICALS AND CATALYST:

1. Eighty-five percent Phosphoric Acid. In coating quartz, normal acid retention is 7-9 lb acid per cu ft of quartz. Catalyst life of 100-200 gal. polymer per lb of retained acid can generally be realized in normal operation before regeneration. Onhand acid inventory must be sufficient to fill one reactor at any time.

2. Quartz as necessary to repack reactors annually.

3. Caustic (and possibly DEA) requirements depend on feed quality.

OPERATING PERSONNEL: One man per shift.

INVESTMENT:

For feed water wash, reaction section and product stabilizer:

BPOD Feed	Investment (ENR Cost Index = 700)
1,000	$ 480,000
5,000	$1,350,000

ANNUAL MAINTENANCE:

Total for materials and labor approximately 3-5 percent of investment, depending on plant size.

California Bulk Acid Polymerization

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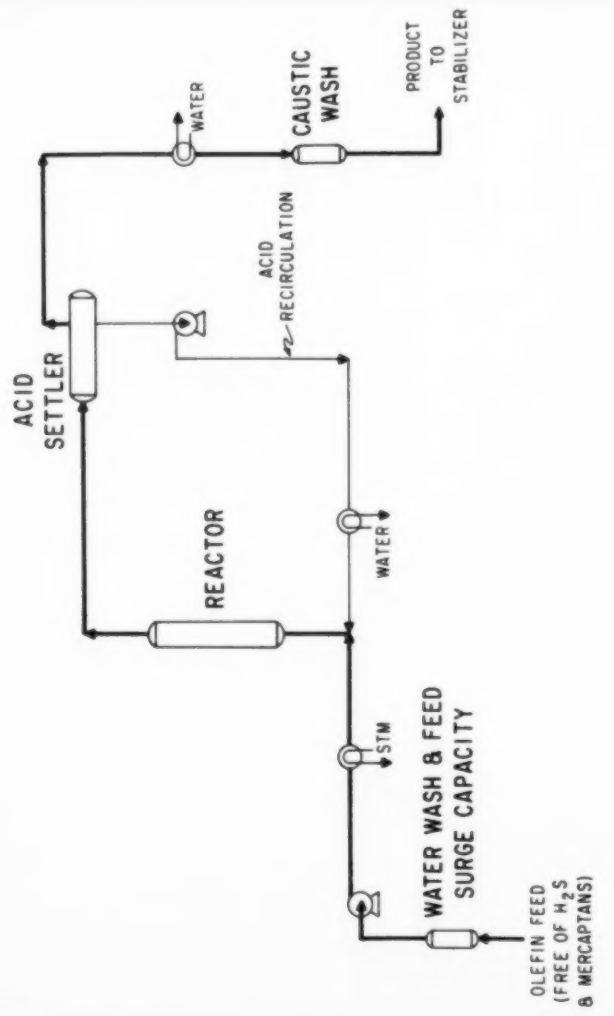

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If corrosion has cut short the service life of your equipment, replace it with Stainless Steel. In the long run, it costs a lot less because Stainless Steel lasts a lot longer. And if you want to be positive of service-tested quality, specify USS Stainless Steel.

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Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

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Du Pont RP-2

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CONTROLS CARBURETOR ICING. RP-2 prevents stalling caused during idling by icing of carburetor throttle plates. Many gasolines require this protection when temperatures range from 22 to 55°F. and relative humidity exceeds 65%.

CONTROLS CARBURETOR DEPOSITS. RP-2 adds a detergent action to your gasolines which not only keeps new carburetors clean, but gradually cleans the throttle plate and throat of carburetors which are already dirty.

CONTAINS PHOSPHORUS. RP-2 contains phosphorus, so you can take a "phosphorus credit" if you're already using phosphorus for control of surface ignition.

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erance at a given air temperature, but the effect varied for each make of car. The final correlation after correcting for an average of a 5 mph wind, has been converted into the convenient nomograph presented as Fig. 3. The use of the nomograph is illustrated by means of this example:

If a gasoline of 8.2 RVP has 28 percent evaporated at 158 F, at what temperature can vapor lock troubles be expected? Use a straight edge to join 8.2 on the RVP (left hand) scale with 28 on the percent evaporated (right hand) scale. This intersects the temperature scale at the required value of 99 F. Vapor locking troubles would therefore be expected with this gasoline at air temperatures of 99 F and higher.

References

1. Domke, C. J.; Tracy, C. B., and Taliaferro, H. R., *Petroleum Refiner*, 32; (7), 151-153, (1953).
2. Co-ordinating Research Council Handbook, 1946 Edition, p. 138, Co-ordinating Research Council, Inc., New York.
3. Taylor, J. E. and Gibson, H. J., SAE Quart. *Trans.*, 3; 307, (1949).

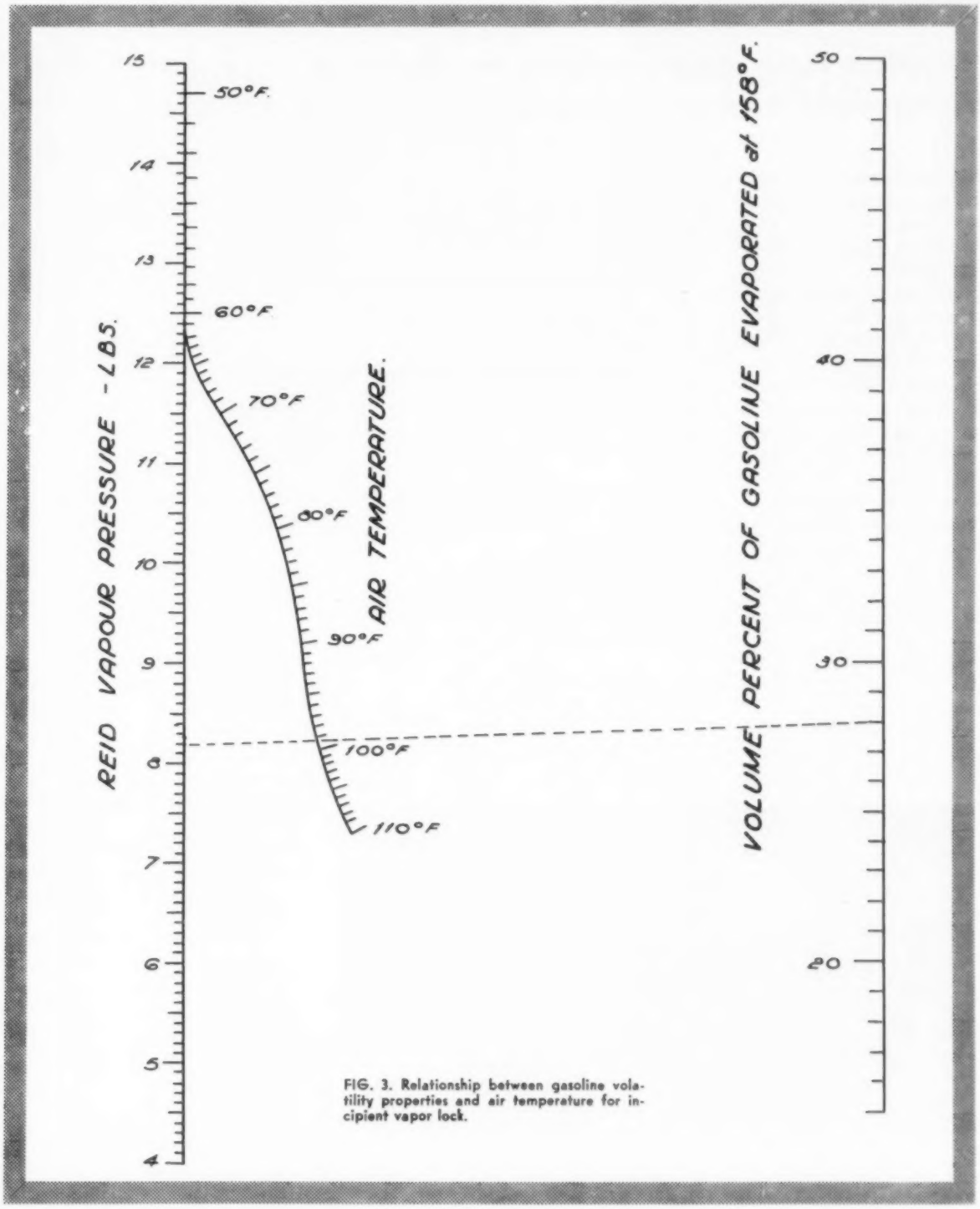
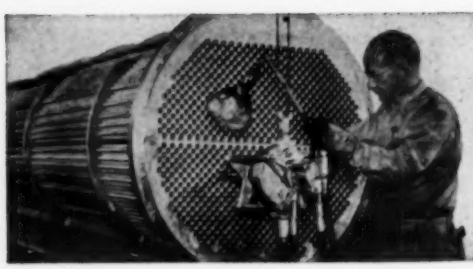


FIG. 3. Relationship between gasoline volatility properties and air temperature for incipient vapor lock.



CONDENSER AND HEAT EXCHANGER CLINIC

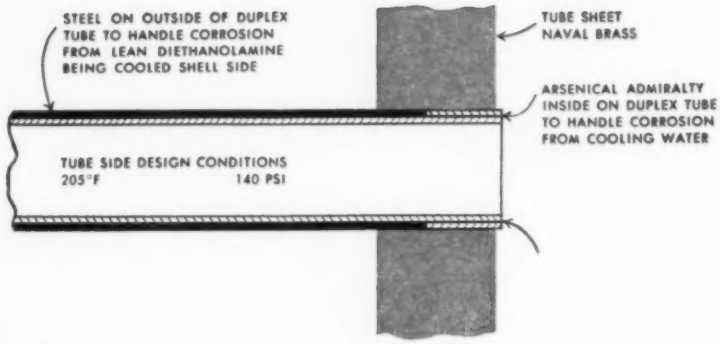
Edited by David S. Hibbard, Metallurgical Engineer
The American Brass Company, Buffalo 5, N. Y.

Duplex tube applications increase as corrosion and temperature-pressure problems grow more complex

New and improved processes in the chemical and petroleum industries—advancing design in power equipment both ashore and afloat, involving ever higher temperatures and pressures—are calling for more and more duplex tubes.

Working closely with both users and manufacturers of heat-exchange equipment, The American Brass Company is expanding its facilities to provide these special-purpose tubes in the combinations of metals and in the sizes and gages to meet new and growing needs.

Dual corrosion problems. Anaconda Duplex Tubes have been most often used to meet situations involving dual problems of corrosion. They are made by drawing tubes of copper or a copper alloy either inside or outside of steel tubes. However, they can be furnished in any combination of metals, including copper or copper alloys with other nonferrous metals or steel in a wide range of diameters and wall thicknesses.

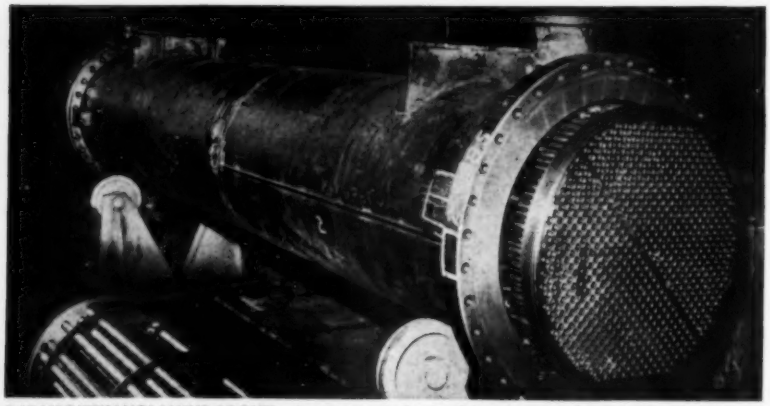

STEEL ON OUTSIDE OF DUPLEX TUBE TO HANDLE CORROSION FROM LEAN DIETHANOLAMINE BEING COOLED SHELL SIDE
TUBE SHEET NAVAL BRASS
ARSENICAL ADMIRALTY INSIDE ON DUPLEX TUBE TO HANDLE CORROSION FROM COOLING WATER
TUBE SIDE DESIGN CONDITIONS
205°F 140 PSI

SKETCH SHOWING CONSTRUCTION of Anaconda Duplex Tubes used in the cooler designed and built by Yuba. Tubes are ¾" O.D. x .065" wall x 16'1⅛" long. The 1¹⁵/₁₆" thick tube sheets of Anaconda Naval Brass are 31⅝" in diameter and 35⅞" in diameter.

For extra strength. More and more Anaconda Duplex Tubes are being used in those applications where internal or external pressures—or the pressure temperature combinations—are too great for a nonferrous tube alone. In this case the nonferrous tube is selected for the chemical properties required for the more corrosive fluid handled; and the steel tube gives the needed strength.

U-bends. Duplex tubes can be readily bent to form the hairpin or U-bend tubes required for the compact U-bend tube design so advantageous in heat exchangers where wide temperature differences exist in the unit.

Technical Assistance. Specialists at the American Brass Company are constantly working with manufacturers and users of heat-exchange equipment, helping to solve process problems. This experience is available to you. For more detailed information on Duplex Tubes, U-bend Tubes, address: The American Brass Company, Buffalo Division, Buffalo 5, New York. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 6879



A LEAN DIETHANOLAMINE COOLER using Anaconda Duplex Tubes (see detail sketch above) designed and built by Yuba Heat Transfer Division of Yuba Consolidated Industries, Inc., Honesdale, Pa. This unit will cool Lean Diethanolamine at the new 19,000 barrels per stream day delayed coker designed, engineered and being constructed for Socony Mobil at Paulsboro, N. J. by The Lummus Company.

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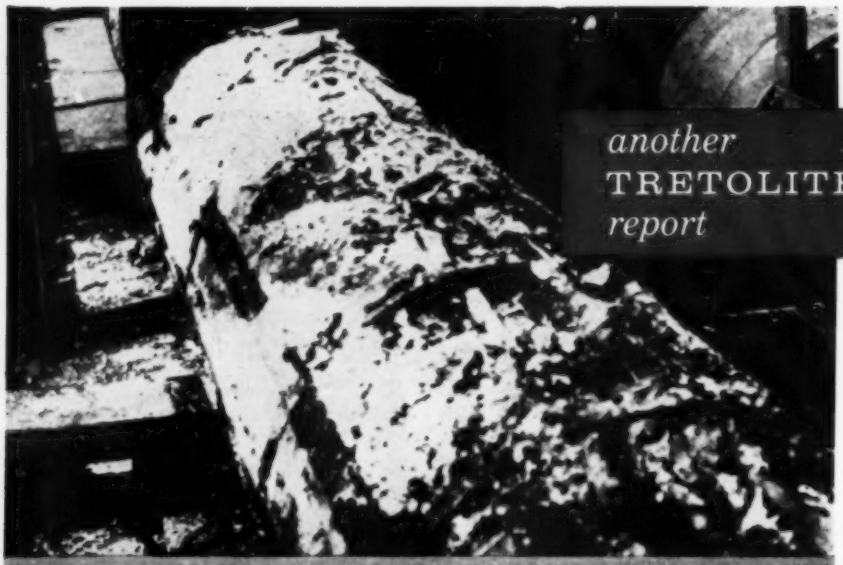

another
TRETOLITE SERVICE
report

See our exhibit at the International Petroleum Exposition, Tulsa, May 14-23, and 5th World Petroleum Congress, New York, June 1-5.

BEFORE KONTOL! *Here's what a tube bundle looked like in one of the heat exchangers of an Ohio refinery — after just 94 days of service. A KONTOL Protection Program has since trebled tube life, upped heat exchange efficiency by more than six million BTU's per hour!*

KONTOL* CORROSION INHIBITOR TRIPLES TUBE-BUNDLE LIFE AT OHIO REFINERY

Also saves $96.00 per day on increased BTU's . . . The effectiveness of KONTOL* protection against corrosion and fouling in tube bundles was dramatically demonstrated in the heat exchange equipment of the crude unit at a large refinery in Ohio.

Since the inauguration of a regular KONTOL Corrosion Inhibitor program, the tube bundle life period has been increased by approximately 3 times the bundle life prior to the use of KONTOL.

KONTOL'S DETERGENT ACTION ADDS DOLLAR-BONUS TO OPERATION

The detergent action of KONTOL Corrosion Inhibitor provided a *plus* benefit for the refinery. A cleaner operation has resulted in the gain of an additional 6,000,000 BTU's per hour—or a savings of about $96.00 per day.

THERE'S A KONTOL PRODUCT FOR YOUR CORROSION PROBLEM

The KONTOL product used in this case was based on a careful study of the refinery's specific needs. The Tretolite Company developed and pioneered the application of organic corrosion inhibitors throughout the petroleum industry. No other organization has Tretolite's wealth of experience and know-how in the manufacture and use of these products. This background (Tretolite corrosion engineers, laboratory and research facilities) is always available to you—to help solve your particular corrosion problems. A call will bring you this service—at no obligation.

*KONTOL *is a registered trademark of Petrolite Corporation.*

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Dave Vondy
Constructive Engineering Company, New Orleans, Louisiana

INSTRUMENTATION has the primary role in maximum product recovery with given plant facilities. Criteria for selecting and using instruments and controls are: Type of process equipment involved, stream composition, effects of expected changes in flow rates and conditions of process streams, effects of operation on related or downstream systems, desired handling of possible emergencies, and requirements for high operating efficiency at the desired product quality.

Cost of Poor Instrumentation

Minimum, poorly designed instrumentation results in excessive operating costs and problems, through reduced equipment efficiency and product give-away. A badly-instrumented fractionating column can, for example, upset an entire process.

Consider a total liquid product de-ethanizer: If the bottoms temperature and tower pressure are held constant, bottoms composition depends on feed composition. If the propane content of the feed increases, ethane content of the bottoms will increase, due to constant lower pressure. Vapor pressure of the plant's propane product will, of course, move up significantly due to the higher ethane content. This is just one of many examples that might be used to illustrate the need for good planning and use of the control system.

Basic Systems

Pneumatic or gas-operated control systems are most commonly found in gas processing facilities. Most engineers are completely familiar with the design and operating principles of such equipment.

A definite trend exists, however, toward the eventual use of electronic control systems, coupled with electro-hydraulic or gas-operated control valves. Electronic control gives faster response and more accurate tracing of erratic operation. Interconnection of electronic components in complex systems is usually more practical than with their pneumatic counterparts. Electronic safety shutdown controls are generally more reliable, more flexible, and simpler. Temperature sensing the thermocouples is as reliable, much more accurate, and allows changes to be followed more closely than with vapor or liquid systems. Finally, remote transmission of data and control information over long distances (500 or more feet) is not practical with pneumatic equipment.

A primary disadvantage of an electronic control system is that a reliable, non-varying power source is required. A short-duration power failure or voltage shift should not be allowed to shut down an entire plant. A second disadvantage is that maintenance of a specialty nature is required. Also, explosion-proof equipment needed for electronic systems is expensive, and many instruments not so housed can't be located in the process area.

Manual Control

In many situations, switching from manual to automatic controls does not significantly improve or ease operations. For example, when a dry desiccant dehydrator is installed at a plant employing full-time operators, automatic cycle switching controls may be difficult to justify. In fact, when reflux rates must be maintained constant, manual control often will be the more practical method.

Distribution of cooling water to several exchangers is another operation in which hand control is more practical. However, the operator must not allow excessive flow through one exchanger, as this will often reduce the cooling efficiency in others. Piston-driven pumps can often be controlled best by hand valves located in the power gas or steam supply line. Normally, automatic control of the main lean oil rate is not practical since a constant circulation rate is desired and direct automatic control of the oil stream will increase pumping horsepower requirement.

Many types of hand valves are built for on or off service only and are therefore unsuitable in throttling operation such as on a motor valve by-pass. There is often sufficient vibration from nearby mechanical equipment to cause many valves to lose position. A means of determining the control obtained must be provided. In many situations, a thermometer or the speed of mechanical equipment will indicate proper control; however, it is often necessary to provide flow indication.

Sensitivity Adjustment

The response of an instrument to changes in the condition being controlled must be adjustable in order to obtain good results. Positive displacement pumps are used to maintain continuous rate of injection of chemical at elevated pressure. Another method includes pressure-equalizing a small pressure tank of the chemical to the flow line and obtaining controlled flow by gravity through a long, reduced-diameter tube. Use of a long tube eliminates the necessity for an excessively small bore which would frequently plug with foreign material. In such application, however, removal of solid particles from the process stream is important. Also, when flow rate is a function of the fluid head, a large variation in rate will occur unless the liquid level is held fairly constant.

Automatic Reset

In an instrument such as a temperature controller, automatic reset is required to reposition the motor valve when there is a change in flow rate. If a temperature controller does not have automatic reset, the output instrument gas will vary as a function of the difference between the sensed temperature and the desired or reference temperature. If the

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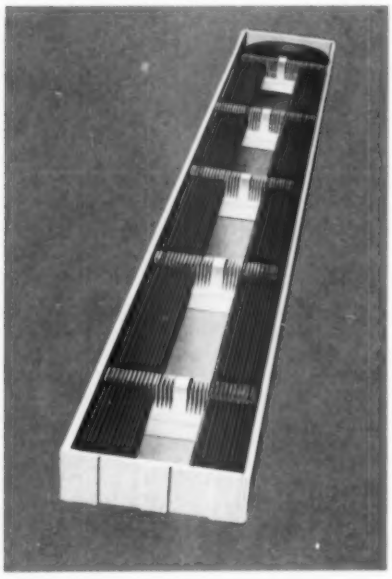
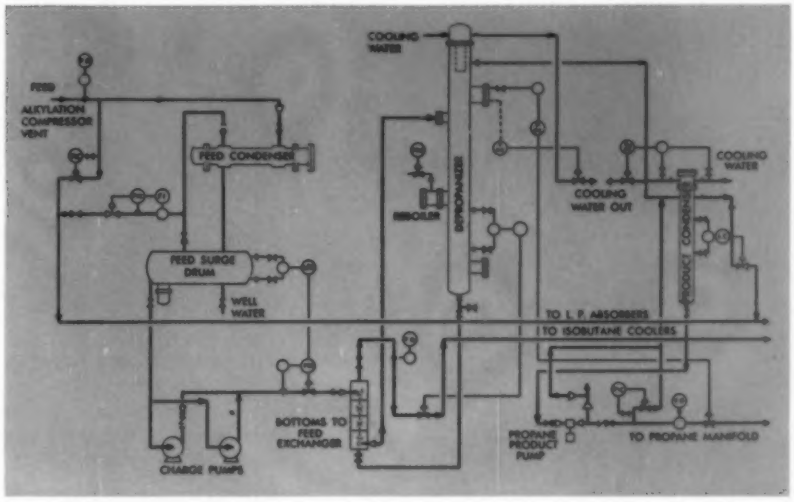
As a direct mill source Wolverine Tube prefabricates U-bend condenser tubes to your specifications — ships them in disposable type pallets in the exact order of their installation — ready for direct insertion into your heat exchanger or condenser.

In addition to real savings in assembly time, you minimize transportation, space and handling problems.

In prime surface form Wolverine U-bends are available in a wide range of sizes and alloys in copper and aluminum. Capacity boosting Wolverine Trufin U-bends (such as those used in this application) are available in copper, copper alloys, aluminum and seamless steel. Wolverine Trufin tubes can be furnished in straight lengths or bent to your specification and packaged as shown here.

Write for complete information — or have your Wolverine sales representative explain their advantages. He is as near as your telephone.





Here's How:

WOLVERINE TRUFIN® CUT COSTS IN ALKY-SYSTEM DEPROPANIZER

BY ERNEST DODD

In refining—as in all industry—using the *right* product at the *right* time can often result in savings amounting to thousands of dollars.

A recent article in a trade publication gives dramatic evidence of the value of low-fin (Wolverine Trufin) condenser tubes in the design of the above low-cost alky-system depropanizer at a large Gulf Coast refinery.

From the article: "The advantage for the internal heat exchangers, low-fin U-tube bundles, lies in the investment savings in shells, floating heads and separate foundations." — "The advantage to this design in terms of the first cost is achieved principally by locating the reboiler and the overhead condenser inside the tower.

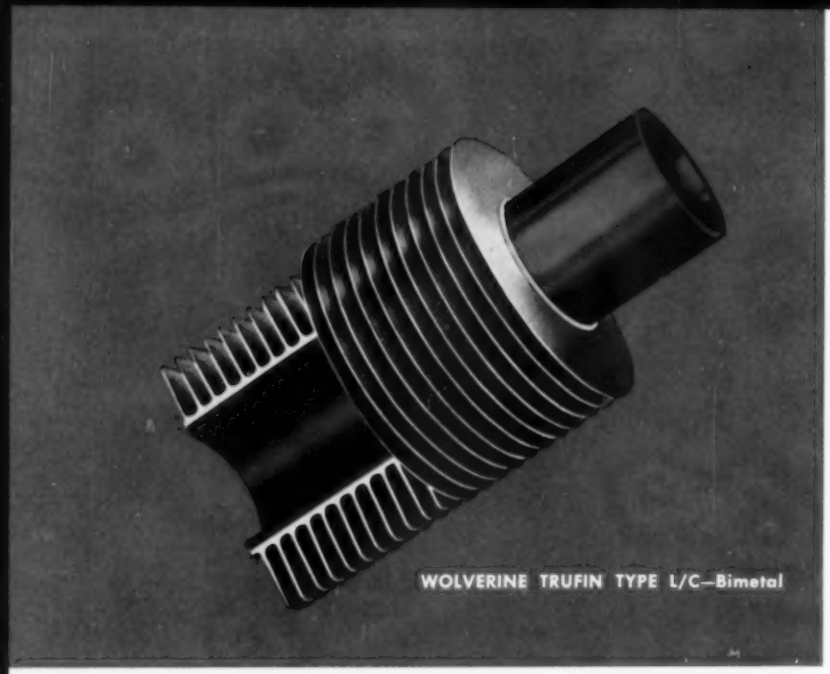
"This was achieved by the use of finned tubes to obtain high heat input per cubic foot of tower volume. It is estimated that the savings in terms of externally located heat-exchanger shells and foundations are about $10,000. This saving is about 25 per cent of the cost of the tower itself, and 6 per cent of the total cost of the project."

The major components in the system were: (a) a feed condenser using 70° well water makeup to the reservoir as coolant; (b) a 60-foot high by 30-inch diameter tower using Spraybak cartridge packing for liquid and vapor contacting; (c) *an internal reboiler and reflux condenser;* (d) an external product condenser doubling as a product accumulator, a bottoms-to-feed exchanger and one product pump.

It was in the area of item (c) that Wolverine Trufin proved its ability as a money saver. Internal mounting was advantageous in this instance because of Wolverine Trufin's greatly increased surface area. This enabled the engineers to get more heat transfer surface into a given area thus obtaining a higher heat input per cubic foot of tower volume.

Where Wolverine Trufin is installed *savings* and *increased heat transfer performance* go hand in hand. Throughout industry authenticated cases such as that described here are becoming daily happenings.

May we suggest that you include Trufin tube in your engineering philosophy when designing heat exchangers for your use?



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PRIME SURFACE DUPLEX TUBING

WOLVERINE TRUFIN TYPE S/T—Duplex

WOLVERINE BIMETALLIC TUBE IS B-R*

* *(BOND RESISTANCE RATED)*

Designing new equipment using bimetallic or duplex type heat exchanger tube?

Then here's good news for you.

NOW — Wolverine Tube can tell you in advance exactly the amount of bond resistance between the inner and outer tubes of mechanically bonded tubing of dissimilar metals.

For example, production testing of Wolverine Trufin® Type L/C assures customers that this high-finned aluminum outer tube can be mechanically bonded to an inner liner of any desired metal and still maintain an assured and predetermined heat transfer rate. Equally precise production testing of resistance values can be given on all other Wolverine finned and prime surface duplex tubing.

With this information determined in advance by Wolverine's newly developed bond resistance testing machine, it is now possible to obtain increased accuracy of design for heat exchangers and condensers using duplex tubing. This is of greatest importance where such tubing is used to combat corrosion.

Write — NOW — for complete information or ask for a Wolverine Technical Sales Representative to call.

Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario.

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instrument is set for extreme sensitivity, however, excess fluctuation will result . . . as the flow rate through the valve increases, the difference between the desired temperature and the actual temperature would increase. In order to reposition the motor valve to handle more fluid at the desired control temperature, it is necessary to reset the instrument . . . this should be automatic and adjustable in response sensitivity.

Automatic reset is also useful in level controllers. Say that a vessel is used to level out surge of flow, and the level controller is set so that the level is at the center of the vessel at the average flow rate. If the average flow rate increases or decreases, the average level in the vessel must similiarly increase or decrease so that the level controller will change the output to the motor valve. The net result is that the surge capacity of the vessel actually used is reduced. With automatic reset, the average level of the liquid in the vessel is automatically repositioned toward the center upon change in average rate.

Usually in setting the automatic reset of an instrument in service, it is not a short time change that is corrected, but the gradual trend which occurs between night and day operation or a cycle that may occur over a period of an hour or more.

Preact

Preact or rate-of-change is often required to level out a recurring cycling condition. In essence, when a change starts to occur, preact causes the instrument to sense that the change will be more than that which is initially indicated. Therefore, the instrument exaggerates the response, overcontrols the motor valve, and reduces the maximum condition which would otherwise occur. This eliminates most of the variation caused by lag in the system in question or that introduced by one or more related systems.

True preact must operate on rate-of-change of the condition being controlled. Excessive application may cause more erratic results than if no preact were used.

Consideration should be given to the effect of change in the condition being controlled. For example, consider the reboiler return temperature to a fractionating column: It may be more desirable to allow this temperature to fluctuate gradually over a reasonable range than to suddenly add a large amount of heat which will cause a surge of vapor return to the column. However, excessive temperature fluctuation must be avoided, and a happy balance obtained.

Interference

A back pressure controller located in a line downstream from a pressure regulator cannot be expected to work . . . two instruments are overlapping in their functions and are attempting to maintain the same condition. Yet, it is not uncommon to find a so-called flow controller of a type which is actually only a pressure controller installed in a pressure-controlled line . . . poor results are obtained, of course.

Recording

A continuous record of principal operating conditions greatly facilitates operation and troubleshooting; however, stacks of old charts do not serve any useful purpose. Strip charts are more practical than circular charts. The time change between charts is now being increased from the old convention of 24 hours to several days (except for sales charts!). In many cases it is practical to install two-speed clocks so expanded charts can be obtained at critical periods. Continuous inking systems are commonly used.

Recording several conditions on a single chart is often practical. A record of temperature on a flow meter chart presents complete data on a single chart and reduces the number of charts used. Sometimes it is difficult to interpret multiple records on a single chart; it is often desirable to change recording ranges after a recorder is in service.

Auxiliary Indicators

To facilitate operation and troubleshooting, auxiliary indicators supplement remote and recording or indicating instruments. At least a pressure tap with block valve should be provided alongside each pressure instrument connection (or inside the pressure line) and a thermowell provided alongside each primary temperature sensing element. Pressure gages should be installed in each pressure vessel (including tanks), around compressor cylinders, and at each pressure controller. Thermowells should be provided around each heat exchanger and sometimes between sections, at the inlet and outlet to heaters and coolers, in compressor suction lines and individual cylinder discharge lines, in engine exhaust pipes, at the base of heater stacks, at the inlet and pit of cooling towers, toward the bottom of each storage tank, at each metering point (be it orifice fitting, positive displacement, gas, liquid, or what have you), and at key points in fractionating columns.

The use of glass stem thermometers rather than dial face is highly recommended to eliminate incorrect temperature indications which may cause considerable operating trouble.

Level Control

Sufficient surge capacity must be provided through the plant so that sudden changes in flow rate are eliminated and sudden changes of feed to columns do not occur. In a vessel where level control must be maintained within six inches, provide additional surge capacity.

Surge requirements is especially important when raw liquids are brought to the plant from the field; a relatively large surge vessel is frequently necessary to avoid overloading fractionation equipment, and still more capacity is desirable to level out the flow rate enough to reduce erratic operation.

Dampening of surges can best be accomplished in

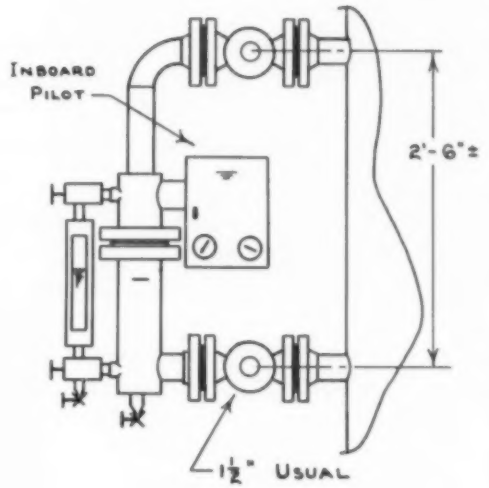

FIG. 50 LEVEL CONTROLLER INSTALLATION

Figure 50

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Carrier

Carrier multi-level refrigeration saves $60,000 in installation costs!

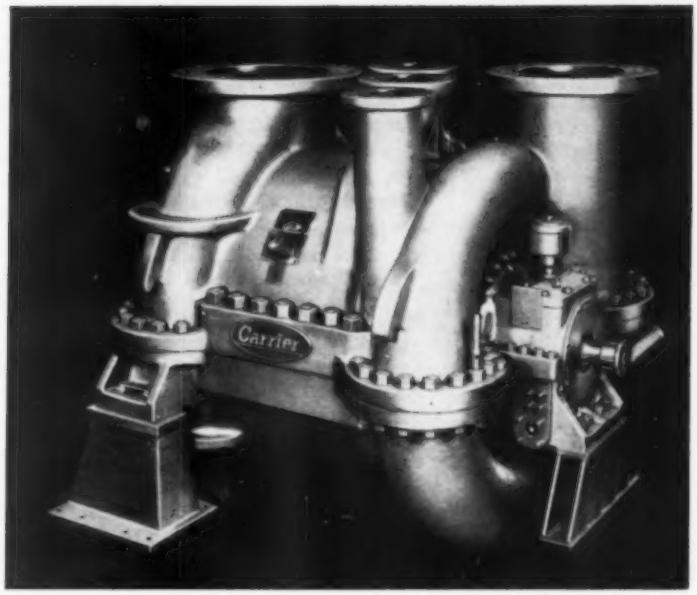
Problem: To provide propane refrigeration at four temperature levels—minus 35° F, minus 3° F, plus 28° F and plus 64° F—in a southwestern natural gas extraction plant.

Conventional solutions: (a) Install four separate compressors. (b) Install two compressors. (c) Install one compressor with no side loads.

Carrier solution: Install a single Carrier Centrifugal Compressor with side loading.

Installation savings: Savings on the installed cost of the single Carrier Centrifugal, exclusive of drivers and their installation costs—in comparison with the conventional solutions (a) $60,000. (b) $28,000. (c) No installation savings, but note big horsepower savings below.

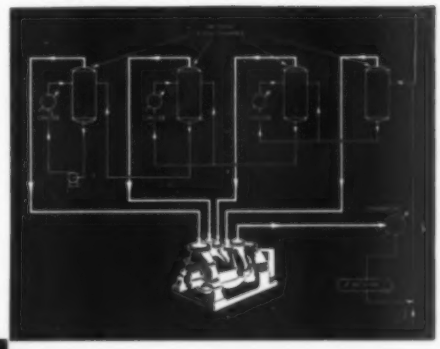
Horsepower savings: Power savings resulting from use of the Carrier Centrifugal—in comparison with (a) none. (b) 1230 hp. (c) 3400 hp.

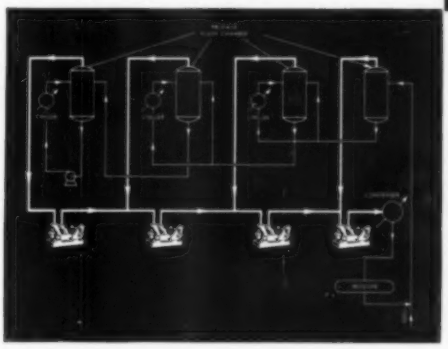


Multi-stage, heavy-duty Carrier Centrifugal Compressors with broad application flexibility are available in capacities up to thousands of tons, depending on your requirements.

Now you can effect substantial savings in horsepower and installation costs by using a single Carrier Centrifugal Compressor for refrigeration in many processing applications. These multi-stage, heavy-duty compressors provide definite installation and operating advantages. For example. Side loading for split load requirements. Extreme flexibility of arrangement with coolers and condensers. High lift or wide temperature range in two to nine stages. Variable inlet guide vanes for capacity control. Suitable for all types of drives. Versatile use with any high-pressure refrigerant.

These big-tonnage compressors are built to the same high-quality standards that have earned Carrier the reputation for round-the-clock dependability in thousands of installations. Carrier specialists draw on experience unmatched in the field. For specific recommendations for your requirements, call the Carrier office nearest you. Or write Carrier Corporation, Syracuse 1, New York.





In a natural gas extraction plant in the Southwest, one Carrier Centrifugal Compressor handling four gas streams with side loading accomplishes the same results as four separate compressors. Compared with the conventional installation, savings on installed cost of the Carrier unit totaled about $60,000, exclusive of driver installation costs.

spherical or horizontal rather than vertical vessels because the rate of change of the level is fast toward critical low or high level, and the bulk of the capacity is provided toward the center of the vessel, where it can be used. Also, there is usually appreciable dead space in the bottom of any vessel. This can be used to maximum advantage only by careful location of nozzles and suitable internal construction for the particular situation.

When conditions warrant the installation, a flow controller may be operated from an orifice fitting in the liquid flow line and be reset with a level controller. However, this method of control is probably little better than level control of the motor valve when the controller has suitable operating response and motor valve is used to smooth flow control. (A valve positioner may be required.)

Only a few situations justify installation of a level controller inside a vessel rather than an externally-mounted unit with isolation valves for service without shutdown, as shown in Fig. 50. Exceptions to external mountings include extremely high pressures and water service in cold climates where freezing trouble is common.

Some level controller designs cause an instrument to have different operating response at different atmospheric temperatures. It is unwise to use equipment having such characteristics. Proper selection of the most desirable combination of displacement element (float) size, shape, and weight, torque tube and lever arm is important in obtaining best results with the torque tube controller.

The limited head differential usually available for operating a differential cell in level control applications discourages use and requires very close manufacturing tolerances for suitable operation at elevated pressures. However, at least one design is finding wide applications. A differential cell is relatively cheap to install, particularly when a controller is to be added to an existing vessel lacking nozzles.

Condensation in the vapor equalizing line to a differential cell is a common source of trouble. A differential cell should have a three-valve piping system like an orifice meter so that isolation is possible.

Pressure Control

Close control of pressure is usually unnecessary except in fractionating equipment and around gas compressors. In any installation the primary sensing point of a pressure controller should always be located several feet from the control device, preferably on the far side of a fitting in the line or in the nearest vessel.

Careful location of pressure control equipment eliminates an excessive compressor horsepower requirement. Appreciable pressure drop in a suction line will significantly increase compression load.

A self-contained regulator specially selected is usually more practical than a pilot-controlled motor valve when a certain pressure is to be maintained in an auxiliary such as a fuel gas system.

High Pressure Reduction

Under adverse conditions (foreign material or liquids in the streams, for example), a substantial reduction in pressure can best be accomplished by a positive choke of material such as borium alloy, carboloy, or ceramic. In many situations it is possible to obtain required control with a positive choke, but when a flexible control is necessary, either a hand adjustable or automatically controlled choke is used. Whenever possible, a choke should be located in a gas stream containing no free liquid . . . downstream from a point of liquid removal.

High-pressure liquids are usually dumped through a snap-acting motor valve which has a positive choke downstream and a screening device upstream to remove solids. A positive choke can often be used. This choke may be simply bar stock drilled out and threaded and used in conjunction with dump valves and drains which serve as a protective device by restricting flow and taking pressure drop off manual valves, thus reducing erosion damage from solids carried in the stream.

Temperature Control

If a temperature controller is to function properly, an accurate temperature measurement must be transmitted to the instrument. Control trouble frequently is traced to a poor sensing device or an unsuitable location of the sensing device. Thermowells are needed so the sensing element can be replaced without shutdown; however, a thick well can cause appreciable lag in the measurement of a fluctuating temperature. Projecting the sensing element well into the process stream will minimize effects of outside temperature. Projecting the sensing element well into the process stream will minimize effects of outside temperature. Also, external insulation will reduce radiation effects if there is considerable difference between the temperature of the flowing fluid and ambient temperature.

The sensing element should be located far enough downstream from a point of mixing to insure that a uniform temperature is reached. This is particularly important when one stream is two-phase or when one stream is vapor and the other liquid. An interesting phenomenon is sometimes found in two-phase flow at low rates. The liquid is at a different temperature than the vapor, particularly immediately downstream from a heater or cooler. Changes in the liquid-gas ratio may thus cause the *indicated* temperature to change erratically, thereby causing the controller to cycle widely.

In many situations, considerable variation in temperature will not produce adverse results. Examples: Temperature fluctuation in a glycol reboiler, final cooling temperatures of lean oil. However, a great deal of fluctuation in the temperatures around a fractionating column will reduce efficiency. Thus, if the feed temperature or the bottom temperature is not held relatively constant, the vapor-liquid ratio in the column will also vary, and of course, operation will be less effective.

Flow Measurement

In the future, most flow measurement will be done by a device rotated by the flowing stream as it measures the weight of the flowing material. This method has proved superior in a system such as jet engine fuel supply.

Liquid measurement is commonly done with positive displacement meters designed for the particular service; thus, for a high vapor-pressure liquid such as LPG, a special meter with vapor return is used to eliminate erratic results due to vapor flow through the meter. The use of metering vessels will increase with more custody transfer and direct pipeline delivery.

Orifice fittings are almost always used for gas measurement; they also find wide application in liquid service. The following is an excerpt from a typical set of specifications:

"Each gas and liquid meter run is to meet AGA specifications, be calibrated, and contain an orifice fitting which will permit plates to be removed while under pressure. The orifice fitting is to be welded upstream and male and female flange downstream. The run length is to be selected for a 0.75 orifice to pipe diameter ratio; straightening vanes may be used to reduce overall length. Two ½-in. and one ¾-in. couplings are to be installed downstream from the required run length. Each differential meter is to record pressure and differential, have a working pressure of 1500 psi, applicable spring and 100-in. water differential range, and a five valve manifold made up of commercial meter valves. Each dif-

ferential meter for liquid service is to be set lower than the orifice fitting which is to have side taps, and not over two changes in direction of flow will be allowed from quiet liquid level in a vessel to the orifice fitting, except downstream from pumps, and the control valve located downstream. Each differential meter for gas service shall locate above the orifice fitting (or drip pots provided in the pressure leads at the instrument) which is to have top taps and lower drain valves provided. Vertical meter runs are acceptable if liquid is flowed upward and gas downward. A set of eight orific plates built in accordance with A.G.A. specifications is to be provided for each fitting; generally these plates are to be ⅛-in. stainless steel, beveled downstream and have a sharp edge upstream, stamped with orifice and run sizes, and packaged edgewise in a wooden box."

Although pipe taps are sometimes used in large meter runs to take advantage of higher metering capacity for a limited pressure differential, usually taps adjacent to a sharp edge orifice are used. To assure accurate differential pressure measurement, it is essential that clean pressure taps are provided . . . internal burrs can cause considerable disturbance and erratic measurement. An inside wall that is not smooth across a welded joint is particularly undesirable upstream from an orifice plate; fitting or flanges should be selected with the same internal diameter as the pipe. Also, the pipe selected must not be out-of-round. For alignment, use larger diameter flange bolts than normal (add 1/16-in.). In installation, don't use gaskets with a reduced hole size. For proper gasket alignment, avoid restriction.

The best and most reliable measurement is obtained in the following order of various types of installations (without special fabrication):

1. Orifice fitting or simple plate holder with integral taps, properly aligned in the run.
2. Threaded or slip-on orifice flanges.
3. Butt-welded orifice flanges.
4. Pipe taps and other installations.

It is not uncommon to find that when threaded or slip-on flanges are used in shop fabrication, the taps must be drilled through in the field. In such instances, care must be taken to obtain clean holes.

Dry bellows-type differential meters are gradually replacing the less practical mercury meters. Although the fact is not universally accepted, with proper calibration a well-constructed dry instrument will give results as accurately as a mercury meter.

Flow Indication

A number of simplified methods allow indication of flow rate without recording. One method is the installation of a manometer or a rate indicator (such as a bob suspended in a vertical tapered glass tube) between the upstream and downstream taps of an orifice installation. In other cases, devices installed in the flow line may be used to indicate flow rate or simply to indicate whether there is flow in the line.

Flow Control

Flow control of a process stream is often necessary to insure desired results. This is the case when a stream is to be divided, or when a small portion of the main gas is to be used for regeneration in a dry, desiccant dehydration system. Flow control is usually accomplished by connecting a differential pressure cell to an orifice fitting. These instruments frequently give trouble in cold temperatures and require antifreeze protection.

Next month in Modern Gasoline Plants: Discussion of plant instrumentation will be continued, emphasizing control and relief valves, special equipment, and examples of control systems.

Ideco's portable H-40 Dual Rambler drilling rigs are credited with reducing the well completion time for Y.P.F. Argentina from 45 days to an average of 15 days. Yes, these dual trailer units really save time, and they withstand years of rugged field service. One example of the special features which assure long-life service from Ideco rigs is protection from corrosion.

The ten H-40's shipped from the U.S.A. to Y.P.F. were given the best corrosion prevention treatment available. Each unit was completely zinc coated, by hot-dip galvanizing or metallizing, at the Nowery J. Smith Co. Large structural parts not suitable for hot-dip galvanizing, because of size or dimensional stability requirements, were protected with special metal spray treatments by competent craftsmen. This extra protection means that Y.P.F. will get better than good service from its Ideco rigs for many years without fear of breakdown due to corrosion.

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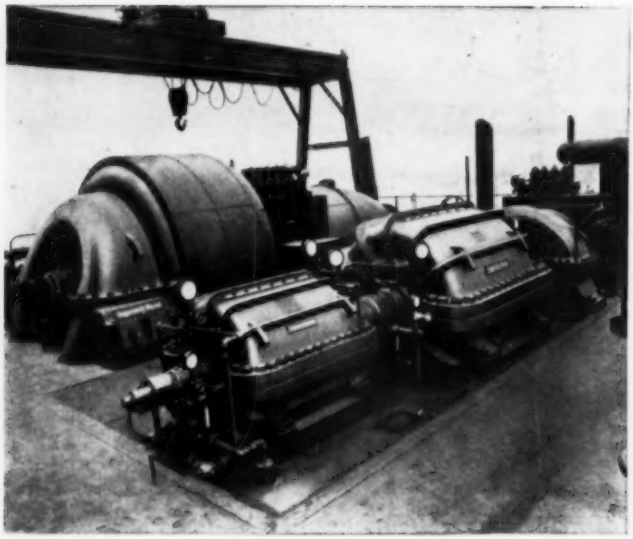
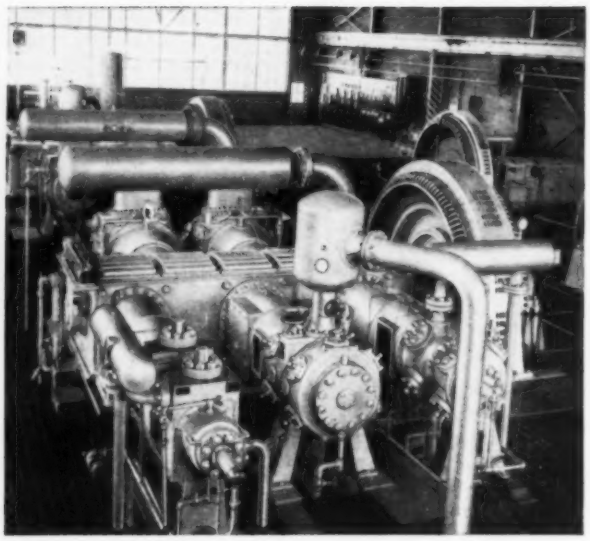
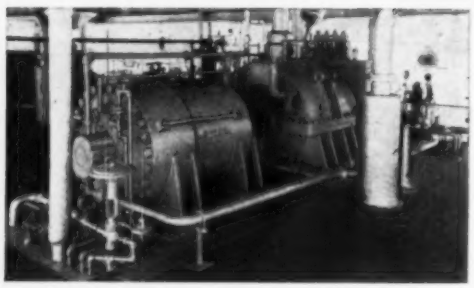


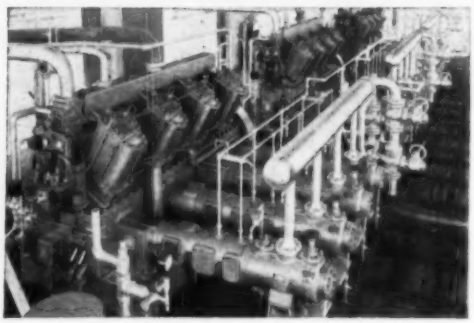
I-R cat-cracking Turbo-Blower rated 122,700 cfm (in background), and two I-R centrifugal compressors in series-tandem rated 20,800 cfm. They are powered by I-R steam turbines, rated 10,000 hp and 6500 hp respectively.



This ammonia synthesis plant has nine multi-stage HHE process compressors totalling 15,100 hp. I-R electric-driven reciprocating compressors range from ½ to 7500 hp.



This Ingersoll-Rand vertically-split centrifugal compressor, handling hydrogen at 675 psi, is driven by an I-R steam turbine rated 5500 hp.



Three 440-hp SVG-NL gas-engine compressors with non-lubricated compressor cylinders recycling hydrogen. Ingersoll-Rand builds 4-cycle, V-angle engine-compressors from 120 to 2000 hp.

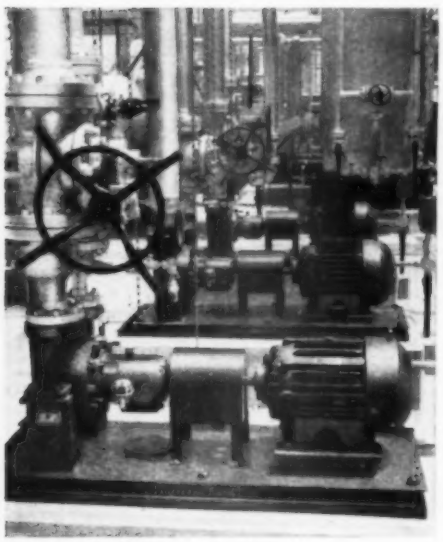
Compressors for every job

Ingersoll-Rand has the world's most comprehensive compressor experience, and builds reciprocating, centrifugal, rotary and jet types in all sizes. Reciprocating units are available in sizes for ½ to 7500 hp, for pressures from vacuums to 35,000 psi. Centrifugal compressors and Turbo-Blowers are offered for pressures to 5000 psi and higher, and capacities to 400,000 cfm. I-R also builds steam turbines to 20,000 hp and higher for a wide range of steam conditions and speeds.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

to the oil industry:

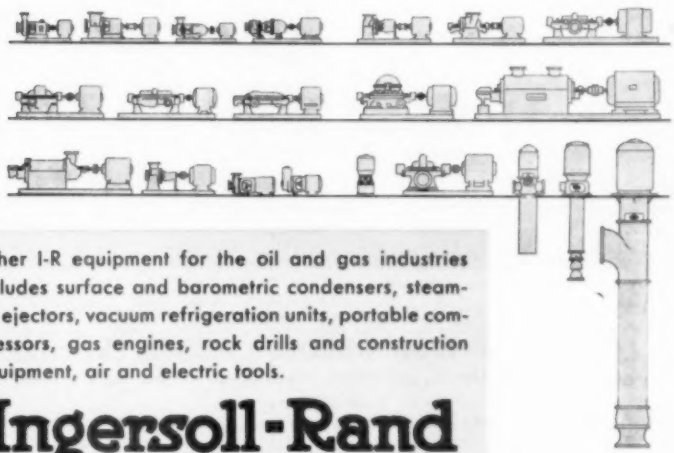
Soon after Colonel Drake discovered oil at Titusville, the history of Ingersoll-Rand began with the manufacture of Cameron reciprocating steam pumps. A few years later, other I-R "ancestor" companies began building compressors and rock drills. Ever since that time Ingersoll-Rand has been growing with the oil and gas industries. Today I-R provides the widest range of compressors, pumps and other equipment for the production, transmission, and processing of oil and gas and their products—the I-R monogram is more than ever a symbol of leadership and progress.



Centrifugal pumps for every service

Ingersoll-Rand offers the most complete line of centrifugal pumps available from any single manufacturer (capacities to 140,000 gpm, total heads to 6500 ft., sizes to 23,000 hp.) There is a size and type to meet the exact requirements of any process application to best advantage. Sustained high efficiency and maximum interchangeability of parts contribute to low operating and maintenance costs.

Photo shows three vertically-split process pumps on debutanizer service. Below are a few of the hundreds of types and sizes of centrifugal pumps built by Ingersoll-Rand.



Other I-R equipment for the oil and gas industries includes surface and barometric condensers, steam-jet ejectors, vacuum refrigeration units, portable compressors, gas engines, rock drills and construction equipment, air and electric tools.

Ingersoll-Rand

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I-R MILESTONES OF PROGRESS

have had a far-reaching effect on the petroleum industry

1860 The first Cameron pump—a reciprocating steam pump which found wide use in the petroleum industry.

1871 Simon Ingersoll's steam-powered rock drill.

1872 Heavy-duty reciprocating compressors.

1902 The first portable compressor.

1906 The first direct-connected synchronous-motor-driven compressor.

1912 First centrifugal compressor for 90-psi air, and powered by I-R turbine.

1913 Centrifugal pump.

1920 Oil-engine compressor engineered as a unit; solid fuel injection.

1924 Large 4500-psi compressors for ammonia synthesis (still operating).

1927 Centrifugal pipeline pump; mechanical shaft seal.

1928 Barrel-type hot-oil charging pump for refineries.

1930 First compressor for 15,000 psi on commercial scale.

1931 Close-coupled Motorpump.

1931 First centrifugal gas pipeline compressor, "canned" with 3000-hp motor.

1933 Famous XVG gas-engine compressors combined multiple power cylinders and compressor cylinders on single frame.

1933 First non-lubricated compressors.

1935 Channel Valves set new standards for compressor valving, unmatched to this day.

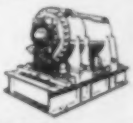
1937 Complete line of vertically-split centrifugal process pumps.

1940 First fluid cat-cracker main air blower.

1947 First high-pressure centrifugal compressor for gas transmission.

1949 First centrifugal gas compressor for cat-cracking.

1952 First turbo-charged gas-engine compressor, the 2000-hp KVS.

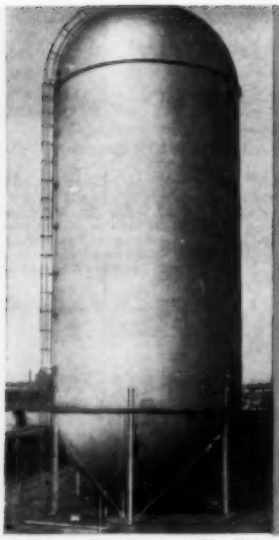


1954 First centrifugal compressor for 2000 psi.

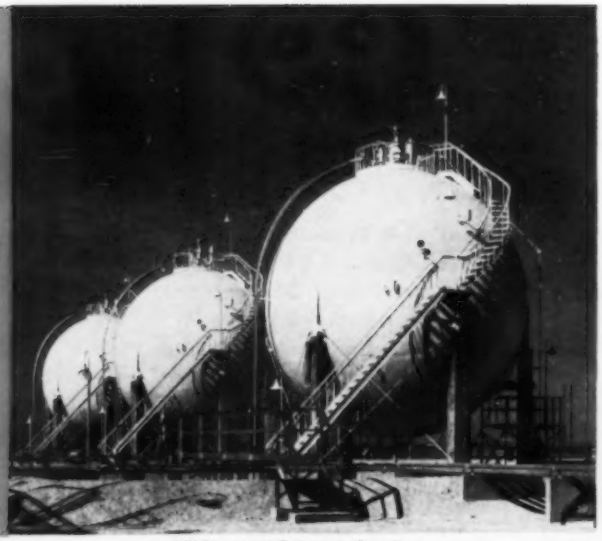
1955 Compressor built for 35,000 psi on commercial scale.

1958 Highest-pressure centrifugal pump —6500 psi.

In engineered products, there's no substitute for *experience*



Pressure Gas Holder, 40′ x 69′



30′ Pressure Spheres, Gasoline

30′ Pressure Spheres, Butadiene

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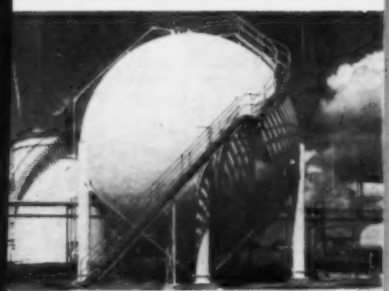

38′ Sphere, 40 psi working pressure

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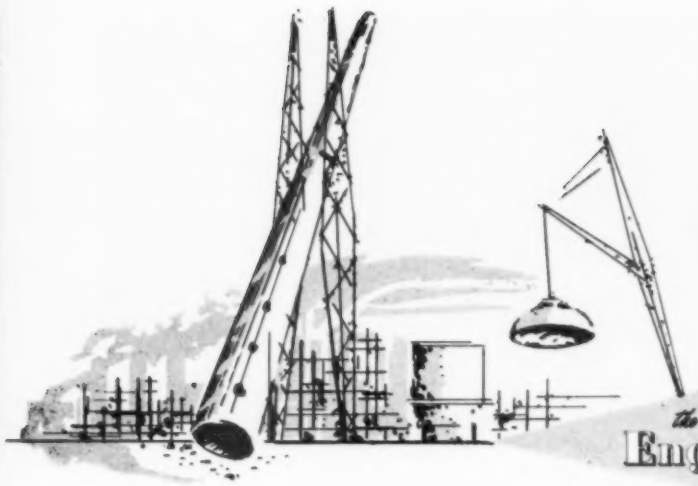

REFINERY CONSTRUCTION MANUAL

PART 8: ENGINEERING DRAWING AND PLANT MODELS

Henry Martyn Noel
New Canaan, Connecticut

THE DRAFTING DEPARTMENT of an oil or engineering company is responsible for most of the drawings which guide the work of procurement and construction. As a result, drafting is the largest branch of the usual engineering organization for designing and building refineries.

In a large oil company's engineering organization, drafting personnel may number over 100 out of a total of 300 engineers, and in a large engineering company's engineering organization, the drafting personnel may number 400 out of a total of 900 engineers. The size of the drafting organization may be limited in some cases by farming work to outside organizations.

Piping design is vitally important, and must be learned by practice more than by books. A good yard piping layout, as compared to a mediocre one, can more than save a designer's annual salary, depending upon the ingenuity in simplifying the valving and abbreviating the lines. Not only is installation cost lowered by good layout, but construction time and eventual ease of operation are affected.

Checking safety is an important part of drafting work. The draftsman must check that the safety rules for guard rails, ladders, etc., are followed. A trained man is needed to see that piping arrangements, sewer layouts, and other items do not contain hazards of gas or water pockets, danger of leakage, breakage, fire or explosion.

Drafting Time

Table 1 illustrates typical drafting times for two modern installations — a simple 12,000 bbl per day pipe still and a 12,500 bbl per day delayed coker. The drafting organization was experienced, and the work went rapidly. Total drafting time was about 10,000 manhours for the still and about 20,000 manhours for the coker.

The still and coker were put into operation 20 and 22 months, respectively, after the contracts were let. The drafting started five and six months after authorization and continued actively on one phase or another for five and six months, respectively, thereafter.

TABLE 1. Breakdown of Drafting Times for Two Typical Cases.

Drawing Items	12,000 BPD Pipe Still, Weeks	12,500 BPD Delayed Coker, Weeks
Piping and sewers	10	7
Structural steel	8	10
Buildings	8	11
Foundations	8	8
Furnaces	10	9
Vessels	6	7
Electrical	11	12
Instruments	10	11

The usual refinery drawings (about six square feet) require about 100 manhours, including supervision. This average figure applies to large, highly efficient organizations, but can vary as much as 50 percent within these organizations. Time needed also varies as much as 50 percent depending upon the type of drawing.

Table 2 lists drafting requirements (total drawings, manhours, etc.) for several typical refinery units. These figures are from the experience of a large engineering company.

TABLE 2. Drafting Requirements for Typical Refinery Units.

	20,000 BPD Catalytic Cracker, incl. Reformer	Offsite Facilities	Boiler Plant	3000 BPD SO_2 Plant
	For 20,000 BPD refinery			
Total drawings	265	480	110	216
Total manhours	25,000	56,000	11,000	20,000
Hours per drawing	95	120	100	92
Piping time, % of total	33	43	50	19
Structures & foundations, % of total time	32	35	35	27
Vessel time, % of total	21	4	0	34
Instrument & electrical time, % of total	7	10	10	12
Supervision time, % of total	7	8	5	8

A detailed breakdown for the cat cracker (combination unit including thermal reformer) mentioned in Table 2 is shown in Table 3. A total of 265 drawings were required. Total drafting time was 25,000 manhours. At 170 hours per month, 15 men should theoretically be able to complete the drafting in 10 months. Instead, the work required 30 men at the peak, and spread over a period of 17 months.

TABLE 3. Detailed Drawing Breakdown for Catalytic Cracking Unit.
(Excluding Supervision)
(Combination unit, including reformer, from Table 2)

	Number of Drawings
Piping (20% of drawings, 36% of time)	
Underground	3
General arrangement of cat structure	2
Catalyst and fractionating	18
Exchanger	3
Pump	5
Blower and condenser	7
Cat handling	2
Furnace	3
Interconnecting	7
Condensate tank	3
Structures, Furnace & Foundations (42% of drawings, 34% of time)	
Structures	
Combination cat cracking	15
Blower and compressor house	3
Blower air intake	1
Car unloading	2
Fractionator tower platforms	4
Control house	1
Cat hopper platforms	1
Pipe supports, blower house	2
Pipe supports, combination unit	10
Pipe supports, yard area	10
Anchors, blower & compressor lines	2
Furnaces (all drawings)	28
Foundations	
Pile plan, combination unit	1
Foundations, combination unit	5
Cat hoppers	5
Cat unloading structure	1
Foundations and floor, blower house	2
Turbo-blower	2
Pump group	3
Exchanger group	3
Waterline anchors	4
Manholes	1
Catch basins	1
Pipe supports	3
Furnace	2
Vessels (18% of drawings, 23% of time)	
Reactor	9
Regenerator	9
Fractionator	16
Catalyst hopper	2
Light fuel oil stripper	2
Distillate drum	2
Steam disengaging drum	1
Fuel oil knockout drum	1
Miscellaneous drums	3
Regenerator stack	3
Electrical, Instruments & General Plans (20% of drawings, 7% of time)	
Electrical & Instruments	
Electrical	13
Instrument panels	5
Panel piping	3
Panel console	2
Piping	7
Piping details	4
Piping schedule	1
Control house layout	1
General Flow Plans & Line Class Sheets & Plot Plans	
Catalytic section flow plan	4
Fractionation section flow plan	2
Pump flushing flow plan	1
Line class sheets, 23 equiv	4
Instrument flow plans	2
Plot plans	2

Scheduling Drawings

Drawings for vessels and structures are usually produced first, and the drawings for instruments and electrical equipment are made last. This is so that requisitioning of long-delivery items can be started as soon as possible.

Usually, more than 90 percent of the drawings for a project are completed several months before the final drawings are made. This long period of tailing off, during which time the final drawings are not made, is usually from either a lack of final data, or from a lack of immediate need for the drawings.

Supplementary Drawings

The preceding has concerned only the drawings made in the offices of the oil company or the construction company. These drawings supply the bulk of the data needed by the procurement engineers and the construction forces.

Supplemental drawings, however, in the form of detailed working drawings are supplied by various suppliers. Steel companies' drawings for structural steelwork; fabricators of pumps, compressors, towers, drums and exchangers furnish drawings to give exact foundation bolt and nozzle locations; and instrument manufacturers and electrical contractors give detailed data for the items for which they are responsible.

The company drawings plus the supplementary drawings

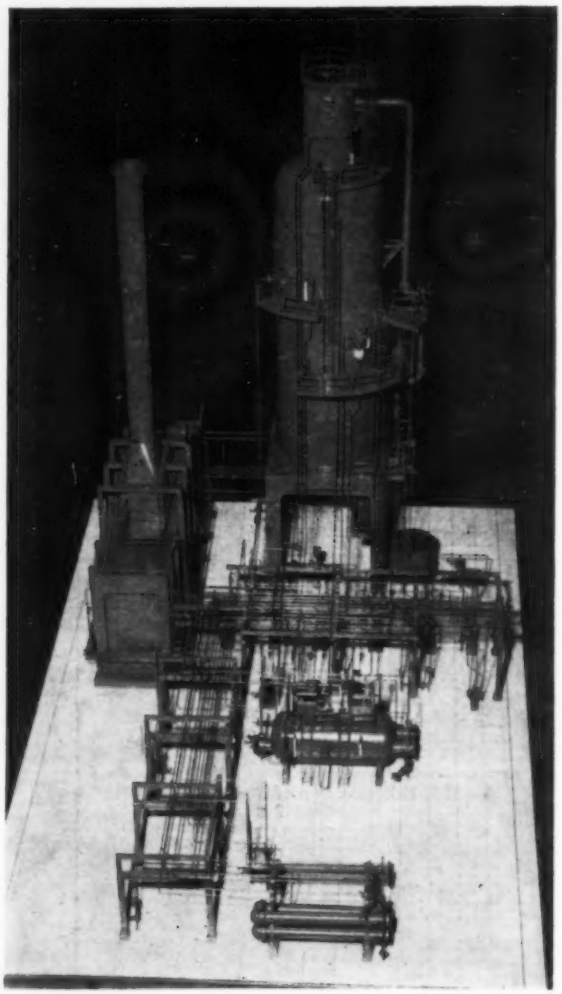

FIG. 1. Rough layout model of a vacuum unit.
— Courtesy The Refinery Engineering Company

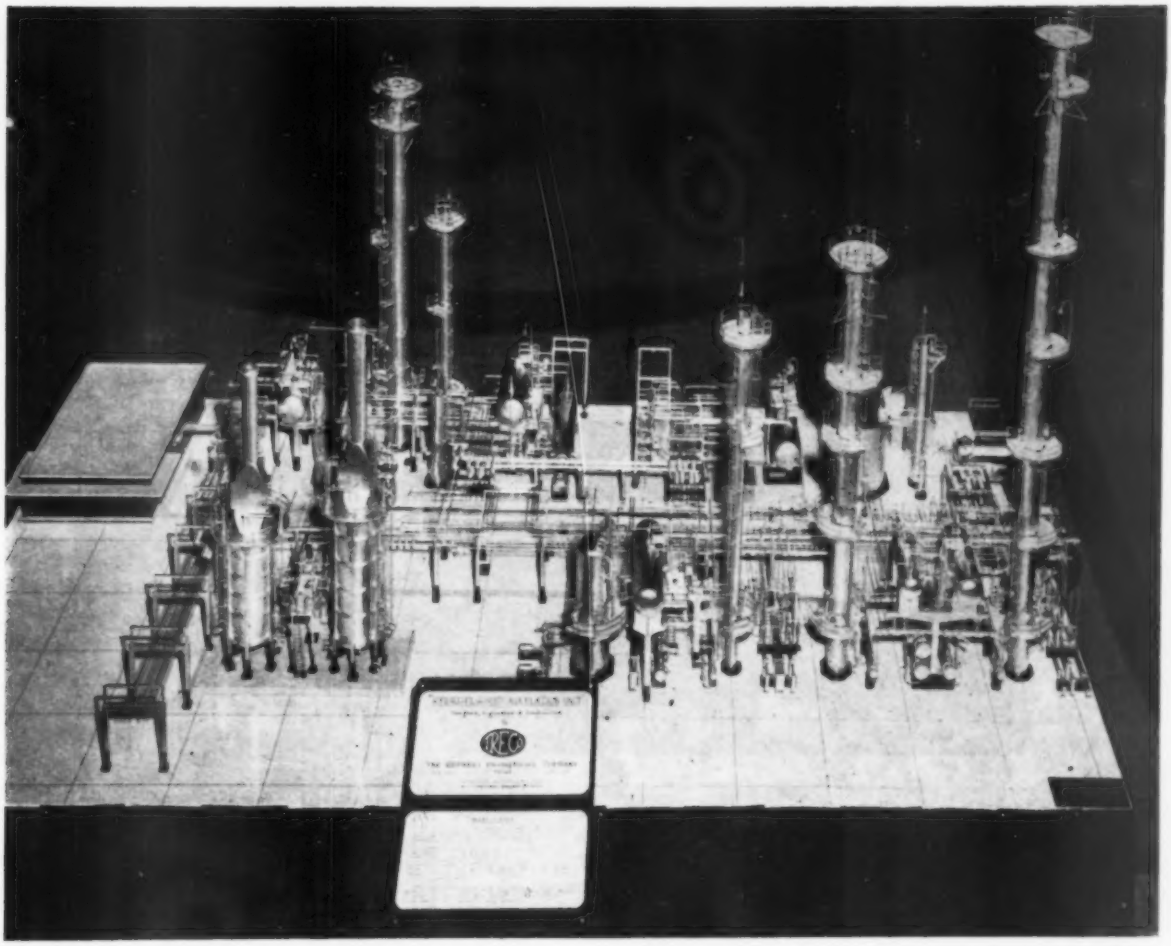

FIG. 2 Display model of an HF alkylation unit. Average cost of models at The Refinery Engineering Company has been one-fourth of one percent of the total cost of the project it represents, while display models such as the one shown can run up to one-half of one percent. — *Courtesy The Refinery Engineering Company*

are used by the mechanical design engineers to prepare a large number of plot plans and unit layouts.

Models

Scale models of process units also have a key role in plant design and in transmitting information to engineers and constructors. Models generally take three forms: (1) rough layout model, (2) design model, and (3) the finished or display model. Examples are illustrated here.

Models are usually assembled from standard scaled parts, such as piping, valves, pumps, and heat exchangers. Vessels and furnaces may be made up from standard parts, or fabricated, depending on size, etc. Scale is most commonly ¼ in. to the foot; however a ⅜ in. scale is sometimes used.

Construction of the model should proceed with the design of the process unit, and should be considered an aid to design . . . not merely a reflection of what may be on drafting paper.

The many uses of process plant models has been well-documented. Time required to construct a model varies considerably, according to the number of prefabricated parts used, degree of exactness, and so forth. It is now common practice to make many photographs of the model, for use in construction activities, perhaps replacing many engineering drawings. ★ ★ ★

WPRA 47th Annual Meeting . . . March 16-18

The technical program of the 47th annual meeting of the Western Petroleum Refiners Association has been completed. The three day meeting, March 16-18, will convene in San Antonio, Texas, at the Hilton Hotel. Technical papers, and the approximate time of presentation, are:

Monday, March 16, 9:30 A.M. — Asphalts

"Looking Both Ways at the Highway Program"
"Progress in Asphalt Technology"
"Getting Our House in Order by Applied Symbiosis"

Monday, March 16, 2:00 P.M. — Fuels

"Highway Safety — a Challenge to Industry"
"The Cloudy Crystal Ball"
"Oils, Greases and Gear Lubricants for Heavy Duty Equipment"

Tuesday, March 17, 9:30 A.M. — Technical Sessions

"Improving Productivity through Better Employee Relations"
"Plain Talk About Computer Economics"
"The Molex Process"

Wednesday, March 18, 9:30 A.M. — Technical Sessions

"Improve Wax Manufacture with MIBK"
"Performance of New Durabead and Heavy Durabead Cracking Catalysts"
"The Texaco Selective Finishing Process"

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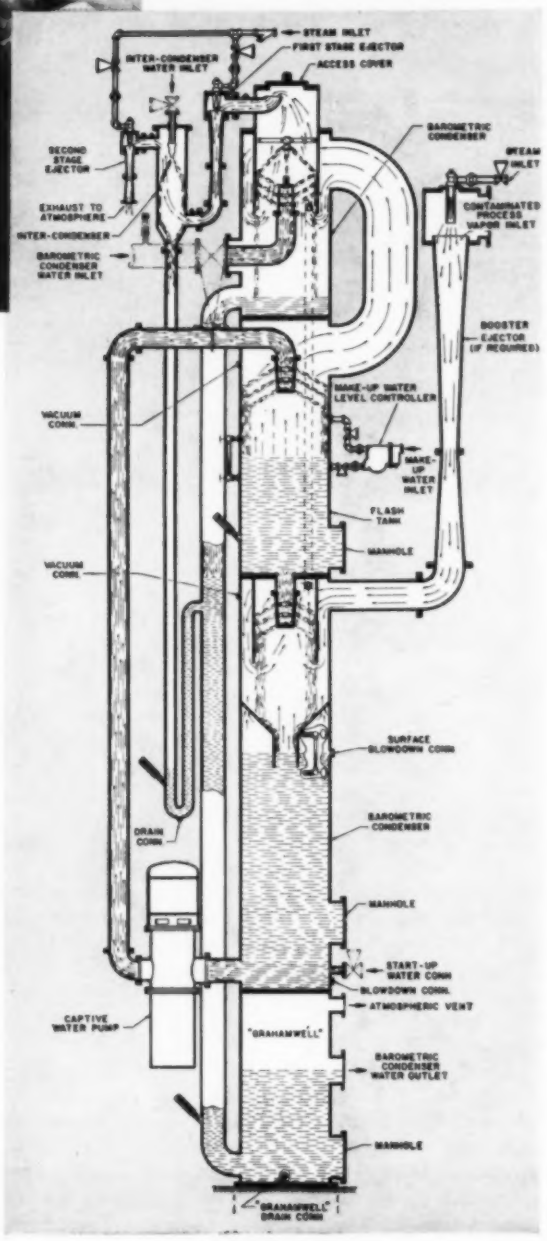

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We call your attention to the unit shown here and suggest that you investigate this unit for your

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Last of three parts on a growth petrochemical . . . HCN

Recovery and Purification of Hydrogen Cyanide from Reaction Gas

Also described here is a process for synthesizing HCN in the absence of air. All commercial plants react methane and ammonia in presence of air . . . but the new process is now in semi-commercial operation

Peter W. Sherwood, *Chemical Engineer, White Plains, New York*

GAS LEAVING THE AUTOTHERMIC REACTOR contains a relatively low concentration of hydrogen cyanide. Typical analyses of reaction gas leaving the catalytic burner are:

	Plant A	Plant B
	Volume %	
Hydrogen cyanide	6.0	6.6
Ammonia	2.0	2.6
Carbon dioxide	0.2	0.3
Carbon monoxide	4.4	3.9
Hydrogen	7.5	6.0
Methane	0.5	0.4
Oxygen	0.1	0.2
Nitrogen	56.3	56.4
Water vapor	23.0	23.7

Separation of ammonia from HCN is the key problem in the recovery stage. Reactor gas contains 0.2 to 0.25 lb of ammonia per pound HCN. The ammonia must be recovered from recycling in the process or in a saleable form, such as ammonium sulfate. Ammonia and HCN are soluble in practically all common solvents. Further, there is a tendency for ammonia and HCN to react in neutral medium to form tarry compounds . . . mostly azulmic acids . . . resulting in yield loss and mechanical difficulties in the process equipment.

Two approaches to separation are possible. Either ammonia or HCN are "fixed" by conversion to stable salts. Treatment with alkaline medium will cause formation of alkalicyanide solution from which ammonia can be stripped. Treatment with acid will form an ammonium salt, while HCN will pass through unconverted.

When HCN rather than one of its salts is the desired product, only the ammonia-fixing approach is commercially feasible. Dilute sulfuric acid . . . or, more precisely, ammonium bisulfate solution . . . is used as scrubbing medium. The resulting ammonium sulfate is sold as fertilizer.

Drawback to this method is that an adequate local market for ammonium sulfate must be available. The HCN manufacturer is not always in position to get full market price for ammonium sulfate. Use of sulfuric acid scrubbing may therefore cause downgrading in ammonia value. In such instances, recovery of ammonia and HCN as such is particularly desirable.

Partial Recovery by Condensation

The reaction gases have a dew point of 60 C. It is possible to recover about one-half of the contained ammonia by cooling to 20 to 25 C. According to Andrussow,[20] the condensate is a solution containing at least 1.2 lb ammonia per pound.

This solution may be worked up by converting the HCN to saleable cyanide salts. The total volume so converted constitutes some 10 to 20 percent of HCN production. Andrussow states that significant HCN polymerization and formation of azulmic acids can be avoided if the condensate is processed immediately and continuously.

Regenerative Recovery Process

A process has been recently developed by which the entire ammonia content of the reaction gas can be separated from HCN without formation of permanent salts. The scrubbing medium is an aqueous solution of 8.3 weight percent

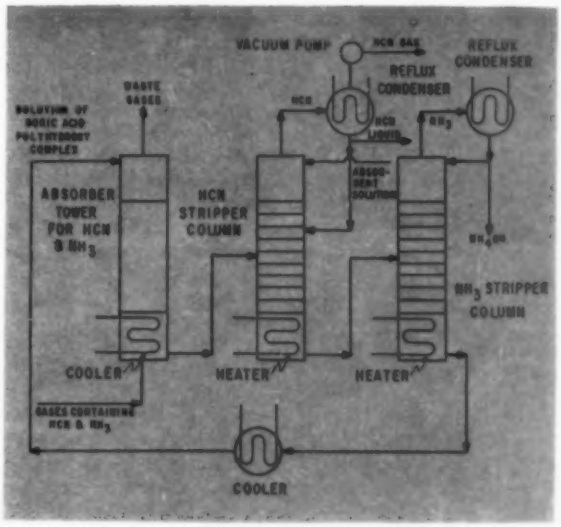

FIG. 1. **Freeport Sulfur Company's process for separating hydrogen cyanide from ammonia.**

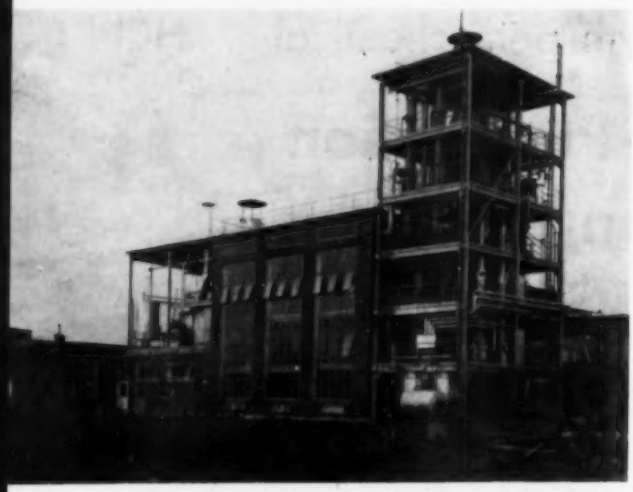

FIG. 2. **Degussa's semi-commercial plant for HCN synthesis from ammonia and methane in the absence of oxygen.**
— Courtesy of Degussa Wesseling

pentaerythritol and 2.5 percent boric acid. This solution will take up both HCN and ammonia. While the HCN is merely dissolved, the ammonia forms a semi-stable salt with the polyhydroxy-boric acid complex. This compound may be broken up by heating to 130 C, whereby ammonia is recovered overhead and the pentaerythritol-boric acid complex is regenerated.

This process has found commercial acceptance. Thus, we have today two principal methods for the removal of ammonia from HCN synthesis gas. These are: (a) Absorption in ammonium bisulfate solution, and (b) absorption in pentaerythritol-boric acid solution. Both are discussed in detail here.

The Ammonium Bisulfate Recovery Method

In this process, cooled reaction gas is passed through a scrubbing tower where it is contacted with an aqueous solution of sulfuric acid and ammonium sulfate. Ammonia-free gas is removed overhead and taken to the hydrogen cyanide recovery stage.

Rich liquor leaving the scrubbing column's bottom is cooled and joined by a stream of make-up sulfuric acid. The bulk of this stream is recirculated to the ammonia absorber, but a portion is taken to a stripper column into which air and steam are injected to remove dissolved HCN. The gas phase is recirculated to the scrubbing tower. Effluent liquor from the stripper is cooled and ammonium sulfate allowed to crystallize from it. This salt is separated, dried and sold.

Temperature, and acid and salt concentration are the key variables in operation of the ammonia scrubbing tower.

In selecting operating temperature, an upper limit is set by two considerations: (1) The need to suppress the reaction $2HCN + H_2SO_4 + 2H_2O \rightarrow 2CO + (NH_4)_2SO_4$, which increases with temperature and with acid concentration, and (2) the need to operate at a point where excessive water vaporization does not occur. The lower temperature limit is set by the desirability of holding HCN dissolution to a minimum.

These requirements leave a fairly wide temperature range for satisfactory operation of the absorption tower, between 80 and 107C. Best results are reported at about 95C.

Similarly, a wide range is allowed for salt and acid concentration in the circulating liquor. It is preferred to operate at the highest feasible acid strength to minimize volume of liquor which must be handled. A practical upper limit is about seven percent sulfuric acid; above this point, separation of ammonium sulfate crystals becomes difficult.

Ammonium sulfate concentration in the circulating liquor is controlled so that the salt solution will be substantially saturated as it leaves the tower. With an acid concentration of 6 to 7 percent, this point corresponds to salt concentration of 35 to 40 percent.

HCN Absorption and Purification

The ammonia scrubbing column is operated at conditions which lead to minimum dissolution of hydrogen cyanide. It is carried in the ammonia-free gases in 6 to 7 percent concentration.

This gas stream is cooled to approximately 20 C and fed to the bottom of an HCN recovery tower in which water serves as washing medium. The scrubbing liquor is slightly acidified with 0.1 to 0.3 percent phosphoric acid to stabilize dissolved HCN. It is introduced to the top of the column at 5 to 10 C.

In this operation, essentially all the HCN make is removed from the gas stream. The stripped gas is flared. Rich liquor leaves the recovery tower with an HCN concentration of 2.5 to 20 percent, depending on operating pressure.

This HCN solution is conveyed to a steam-heated stripping column. Here, the HCN content of the liquor is reduced to 0.02 percent. This stream is cooled and recycled to the HCN recovery tower.

Overhead from the stripping section is an aqueous solution containing 50 to 60 percent hydrogen cyanide. A simple fractionation step . . . using four to five theoretical plates at 50 percent reflux . . . suffices to raise HCN concentration above 99 percent.

Recovery in Boric Acid-Pentaerythritol Solution

This process, developed by Freeport Sulphur Company,[18] is based on the finding that aqueous solutions of a boric acid-polyhydroxy complex will form an addition compound with ammonia that can be decomposed at elevated temperature. Hydrogen cyanide, on the other hand, does not enter into this complex.

Scrubbing solution is made by mixing an aqueous boric acid solution with a polyhydric alcohol. Updegraff[19] states that a solution of 8.3 weight percent pentaerythritol and 2.5 percent boric acid gives the most satisfactory performance.

Fig. 1 shows the flow scheme employed for this method of ammonia recovery. Typical operating conditions call for a flow of 500 lb scrubber solution to remove 1.4 lb ammonia from the feed gas.

Scrubbing liquor enters the absorption column at 25 C and leaves at about 35 C. This stream contains essentially all of the feed ammonia in the form of an addition compound and the hydrogen cyanide as a simple solution.

Removal of HCN from solution is done in a stripper column operated at 85 to 90 C and 10 to 20 mm Hg abs. Hydrogen cyanide is refluxed to this column and a stream of liquid HCN withdrawn as product. Recovery is nearly quantitative and purity better than 99 percent.

HCN-free solution is taken to an ammonia stripper column. Here the scrubbing liquor is regenerated, while ammonia and water are taken overhead by heating to approximately 25 psig and 125 C, at which temperature the addition compound is decomposed.

The resulting ammonium hydroxide solution is taken to a secondary stripper, operated at 50 psig and 205 C. Here, ammonia is removed overhead to be recycled to the HCN synthesis reactor. Liquid effluent from the secondary stripper is water. Purpose of this operation is to bleed from the system an amount of water equivalent to the quantity formed in the HCN burners. By maintaining water balance in this manner, dilution of the absorption liquor is avoided.

Another Example of Skill With Alloys

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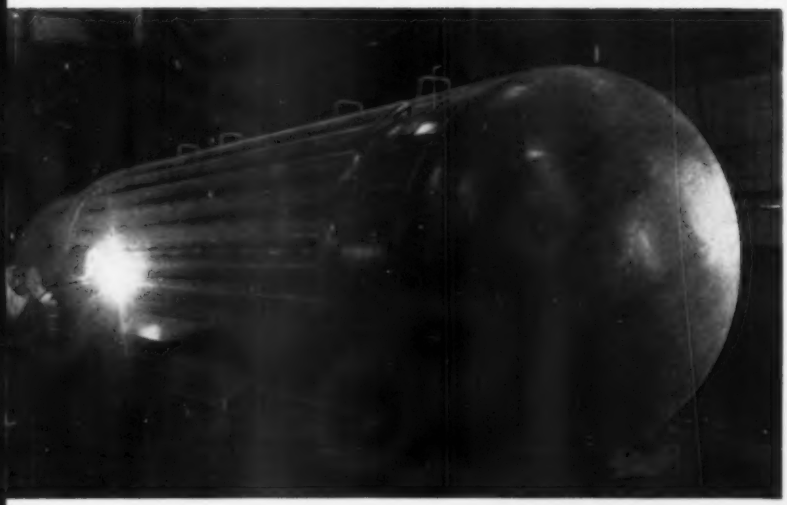

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HCN Synthesis in the Absence of Oxygen

While autothermic processes are the basis for all commercial production of HCN from methane and ammonia in the United States, direct synthesis in the absence of oxygen has certain intrinsic advantages. Most important is reduction in gas volume to about one-third the amount which must be handled when air is used as combustion agent. This permits a corresponding decrease in the size of recovery equipment. Also important is the reduction in side reactions, notably in the decomposition of ammonia.

Considerable effort has therefore been made on development of an oxygen-free process for HCN synthesis. Furthest advanced is a process developed by Germany's Degussa.[24,25] This method has been proved on a pilot-plant scale and has, since late 1957, been used in a 2.7 million lb per year semi-commercial unit.

In this plant, HCN yield is 91 percent based on methane (excluding fuel gas requirements) and 85 percent based on ammonia. About 10 percent of the feed ammonia is recovered as ammonium sulfate.

The reaction is carried out at 1200 to 1300 C in the presence of a specially-formulated catalyst containing 70 percent platinum. Process gases pass through ceramic tubes in a pipe still and are heated by the burning fuel gas in the unit's combustion chamber.

Key to the process is the design of the reaction furnace. In Degussa's semi-commercial unit there are two such furnaces, arranged as mirror images. Each converter contains 13 ceramic (burned aluminum oxide) tubes, 20 mm diam and 2 meters long. The inside surface of the tubes is coated completely with the catalyst composition, applied as a 15 micron film.

The tubes are joined into a cooled head at the outlet side. In this tube head, the temperature of the reactor effluent is lowered quickly from 1200 C to 300 C.

The cold ends of the reaction tubes are connected to the distributing head for the entering process gas by means of flexible bronze hoses. A high temperature gradient exists at this point. This would damage the ceramic tube if sufficient expandibility were not provided.

Fuel gas and air are introduced to the pipe still's combustion chamber, preheated to 400 C. Flue gases pass through a waste heat boiler. Fuel gas requirements are about 29,000 Btu per lb HCN produced.

As is the case in autothermic HCN synthesis, process feed gas must be free of sulfur, metal carbonyls, and higher hydrocarbons. Presence of carbon monoxide and hydrogen is objectionable only in that these components increase the gas volume which must be handled.

Feed gas ratio must be carefully controlled. At steady-state, the ammonia-methane ratio is maintained at 1.05. Excess methane is particularly objectionable because it causes soot formation and therefore catalyst fouling. For this reason as well as to reduce explosion hazard, methane is introduced last and turned off first during start-up and shut-down.

The raw reactor gas contains 22.9 percent HCN, 2.5 percent ammonia, 71.8 percent hydrogen, 1.1 percent nitrogen, 1.7 percent methane plus carbon monoxide. Its HCN content is thus about 3.5 times the concentration obtained in autothermic burners.

Degussa's system of ammonia removal and HCN recovery is similar in principle to the ammonium bisulfate method described above. The tail gas obtained consists of 96.2 percent hydrogen, 2.3 percent methane, and 1.5 percent nitrogen. It is suitable for direct use in hydrogenation processes; its value as a by-product must be given weight in economic evaluation of hydrogen cyanide synthesis in the absence of oxygen.

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★ ★ ★

IPE Hall of Science Petrochemical Exhibit Planned

Thirty acres of exhibits shown by more than 1400 companies and valued at more than $500,000,000 will highlight the 1959 International Petroleum Exposition, May 14-23, at Tulsa, Oklahoma. More than 30,000 oil men, plus representatives from countries around the world, are expected to attend the IPE's Exposition, commemorating the centennial of the petroleum industry.

At right, planning a coordinated exhibit for the Hall of Science, are members of the Petrochemical sub-committee. Standing, left to right, are: Calvin E. Cox, manager of organic raw materials purchasing, Dow Chemical Company, Freeport, Texas; W. B. Strobel, special projects coordinator of Continental Oil Company, Houston, Texas; John R. Stitt, coordinator of marketing, Oronite Chemical Company, San Francisco, California; and Karl J. Nelson, vice president and sales manager, Enjay Company Inc., New York City. Seated are J. A. Sherred, development director of Lion Oil Company Division, Houston, Texas; and Chairman Richard M. Leader, manager of the special products division, Phillips Petroleum Company, Bartlesville, Oklahoma.

Members of the Petrochemical sub-committee of the Hall of Science Committee for IPE plan their exposition exhibit.

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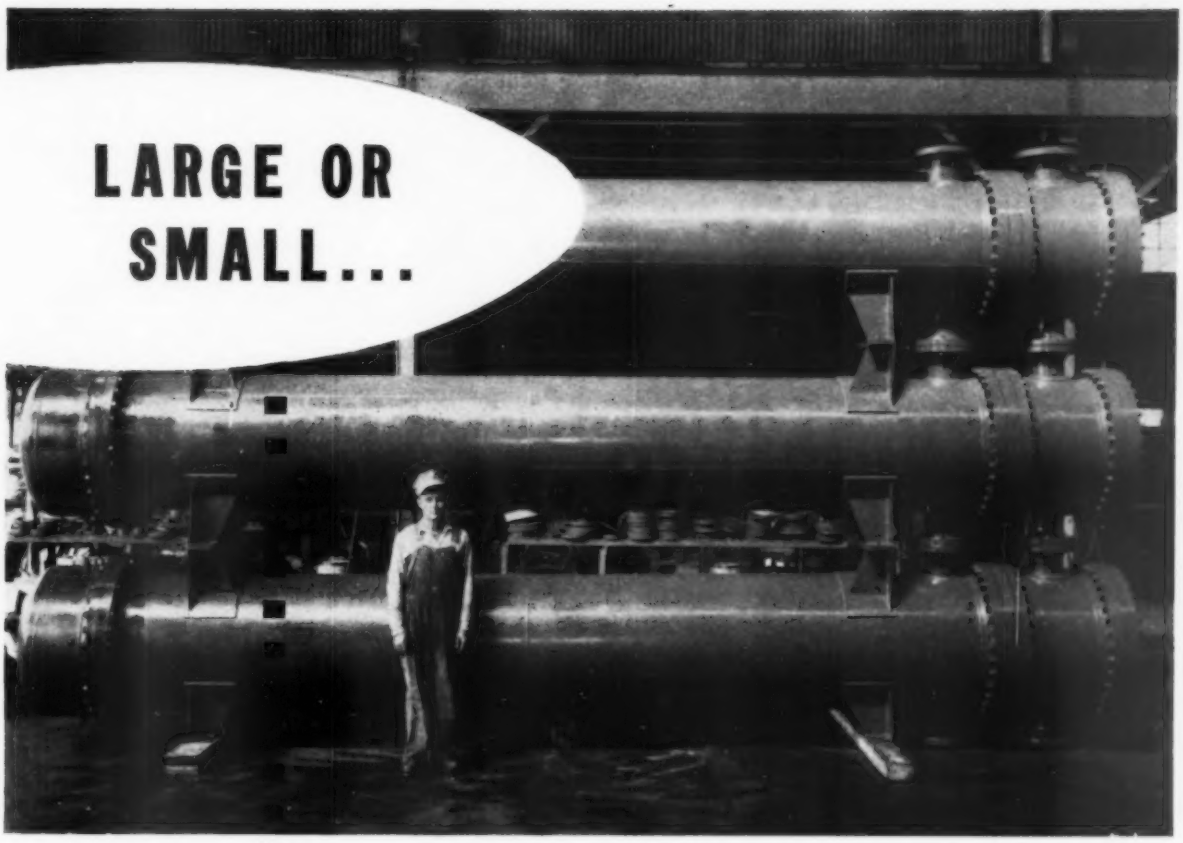

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Refining Personals

▸ Three appointments at the new Petrothene polyethylene plant of U. S. Industrial Chemicals Company, Division of National Distillers and Chemical Corporation, have been announced.

T. H. Dantzler

T. Howard Dantzler will be superintendent of operations at the plant, to be completed early in 1959 at Houston, Texas. **Eugene C. Carlson** is technical superintendent; and **E. P. Richards** has been named chief engineer. Richards and Dantzler were formerly located at the company's Tuscola, Illinois, plant, while Carlson was in the Chemical Development Department, New York.

E. C. Carlson

E. P. Richards

▸ **Dr. Donald R. Lewis,** senior research chemist at Shell Development Company, has been elected chairman of the Southeast Texas Section of the American Chemical Society, for 1959. Other new officers include: **Byron L. Williams,** of Monsanto, Chairman-Elect; **James V. Covender,** Monsanto, Secretary; Treasurer **Thomas C. Ponder,** of Gulf Publishing Company's *Petroleum Refiner*.

W. O. Milligan of The Rice Institute and **Clyde S. Brooks** of Shell Development Company were elected councilors. Directors chosen were **W. H. Lane,** Monsanto; **J. A. Ridgeway,** American Oil Company; **Albert Zlatkis,** University of Houston; **G. E. Crain,** Diamond Alkali Company of Houston.

▸ **Murrell D. Long** has been appointed production superintendent by Girdler Catalysts, Louisville, Kentucky, a unit of Chemetron Corporation's Chemical Products Division. Girdler manufactures specialty catalysts for petroleum and chemical process applications.

▸ Six promotions in American Oil Company's Research and Development Department have been announced. **C. N. Sechrist** has been named group leader; **B. M. Drinkard,** senior chemist, group leader; **F. M. Jacobsen** and **F. E. James Jr.,** promoted to senior chemical engineers, will retain group leader designations; **R. L. Stack,** administrative supervisor; **William Schoen,** senior chemist.

▸ **Leonard L. Huxtable** is the new manager of Ethyl Corporation's Western region sales department, succeeding **Meredith Littlefield,** who has been granted a leave of absence. **J. O. Balzer** was named to succeed Huxtable as assistant manager of the Southern region, and **J. E. Hendrick** will take Balzer's place as district manager of the Houston office.

▸ The election of **William P. Gee** as vice president in charge of foreign petrochemicals for The Texas Company has been announced by **Augustus C. Long,** chairman of the board. Since 1954, Gee has been president of Texas-U. S. Chemical Company, jointly-owned subsidiary of The Texas Company and United States Rubber Company.

▸ **Walter A. Bauer** has joined Gulf Oil Corporation as a sales representative in the petrochemicals department, and will be headquartered in the Gulf Central Offices in Pittsburgh, Pennsylvania.

▸ **E. R. Behnke** has been appointed manager of Molecular Sieve products by Linde Company, Union Carbide Corporation. He is responsible for sales, production and technical development of the molecular sieves, which are used industrially in petroleum refining, chemicals manufacture and metal processing. Benke was formerly sales manager for the sieves. **J. D. Steinhagen,** formerly a salesman for the Linde products, has been appointed sales engineer for Molecular Sieves.

▸ **Kurt K. Rumpf,** former works manager of the Hamburg-Neuhof refinery of Oelwerke Julius Schindler GmbH., is now technical director of OMV, in Vienna. In Rumpf's new capacity, he is responsible for all OMV's crude refining activities, including planning work for the large-capacity Schwechat refinery.

▸ **Don Swanson,** former sales representative for The Vickers Petroleum Company, Inc., has been promoted to Kansas Division sales manager. Added to the Vickers sales staff in a recent retail sales department expansion were **Don Cuthburtson** and **H. D. "Hank" Hamilton.**

▸ Appointment of **G. Thomas Shantz** as product manager for petroleum chemicals has been announced by Olin Mathieson Chemical Corporation. Shantz, who will have charge of sales and market development of oil additives, will be located at Baltimore.

G. T. Shantz

E. H. Brown

▸ **Edwin H. Brown** is now vice president-finance of Commonwealth Oil Refining Company, Inc., at Commonwealth's home office in Ponce, Puerto Rico.

▸ **A. P. McGuire** has been named plant manager of the American Chemical Corporation plant now being constructed at Waston, California. AMC, jointly owned by Richfield Oil Corporation and Stauffer Chemical Company, plans to produce ethyl chloride, ethylene dichloride, vinyl chloride monomer, perchbethylene, trichlorethylene and plastic polymers and copolymers, from raw materials furnished by the parent firms.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Personals

Arthur E. Bowe has been named laboratory manager, and **Frederick B. Stehr** sales promotion coordinator, in the Western Region office of Du Pont's Petroleum Chemicals Division at Los Angeles.

Alan H. Brown has been assigned to Eastern Venezuela as field engineer with South American Petrolite Corporation. For the past year, Brown has been on special assignment with the Tretolite Company division, at St. Louis, Missouri.

Two new managers have been appointed by Kerr-McGee Oil Industries, Inc. **Samuel W. Harris** will have charge of the Wynnewood, Oklahoma, refinery and **Bernard A. Paulson** the Cleveland, Oklahoma, installation.

Robert W. Woollen is the new assistant treasurer and manager of the Accounting Department of Petroleum Chemicals, Inc. Woollen will assume the duties of the late **A. L. Green Jr.**, former comptroller.

A. T. Proudfit has been elected director and president of Creole Petroleum Corporation, succeeding **H. W. Haight.** Haight resigned to become director and chairman of the board of directors of The Carter Oil Company, subsidiary of Standard Oil Company (New Jersey). Proudfit served as president of Creole from 1945 through 1954, resigning to become a director of Standard Oil, the position he relinquished to return to Creole.

A. T. Proudfit

B. L. Majewski

Bernard L. Majewski, president of Great American Oil Company, has been elected a director of Universal Oil Products Company, filling the vacancy left by **Fred C. Koch's** resignation. Majewski is also president of Signal Perfect Fuels, Inc. and a director of Crescent Corporation.

C. E. (Gene) Gessner, formerly staff assistant engineer, has been promoted to general superintendent, natural gasoline division, Kerr-McGee Oil Industries, Inc.

Gene B. Brown has recently been appointed a sales representative in Gulf Oil Corporation's Petrochemical Department. He will engage in sales and sales development of petrochemicals products, at the Gulf Building, Pittsburgh.

J. H. Corbitt has joined Technical Division at Humble Oil & Refining Company's Baytown, Texas, refinery. **H. L. Bauni Jr.** has returned to the division from military service.

William P. Gee, president of Texas-U. S. Chemicals Company, has been elected vice president in charge of Foreign Petrochemicals for The Texas Company, a parent company, with U. S. Rubber, of the chemicals concern.

Carlos M. Creamer has succeeded **Lionel J. Bourgeois** as manager of the Marketing Department of Creole Petroleum Corporation, at Caracas, Venezuela. Bourgeois has been transferred to Standard Oil Company of New Jersey.

DRESSED FOR WORK!

You can put overalls on a man, but can you expect a man's thoughts to "wear working clothes?"

We think so. That's why—once you tell us your requirements for a process such as reforming—you can expect us to show up ready to *work*.

You can also expect new ideas. And with them comes wide experience in catalysts, catalyst research, pilot plants and all grades of charge stocks. This is your assurance of results—top efficiency from the Houdriforming or Iso-Plus Houdriforming process best for producing high octane gasoline or aromatics from your raw materials.

Our "shirtsleeve-kind of service" continues—to help you maintain peak efficiency—*after* the process goes on stream. Mentally and physically, we *stay* dressed for work as long as we're serving you.

*HOUDRY

PROCESS CORPORATION

1528 Walnut Street, Philadelphia 2, Penna.

*Houdry means Progress...through Catalysis

It's New

Refining - Processing Equipment

For Complete Information on Items Described Here, Use Enclosed Reply Card.

Valve Assures Viscous Flow

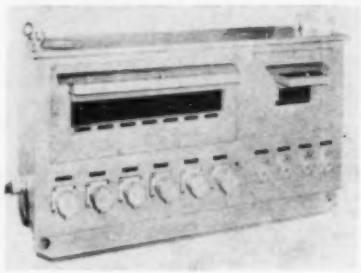
A newly-designed steam-jacketed valve assures constant temperature for viscous materials which congeal or harden at normal temperatures. Among the materials which this valve will handle are tar, asphalt, pitch, paraffin, waxes, coal tar products and molten sulfur. Flow is permitted in either direction according to the manufacturers, *Everlasting Valve Company*.

Circle number (41) on reply card.

Plastic Fittings

A complete line of full-flow molded plastic pipe fittings with grooved ends, for quick-jointing plastic pipe, has been announced by *Victaulic Company of America*. In sizes from 1½ to 8 in., the fittings are available in regular polyethylene, special high temperature linear type polyethylene, and polypropylene. Fittings available include elbows, tees, crosses, 45 deg laterals, reducers, caps and flanged adapter nipples.

Circle number (42) on reply card.



Unique Portable Power Centers

Weatherproof, portable power center for welding crews acts as self-contained distribution unit for 440, 220, and 110-v utility lines. One heavy duty cable connects the center with nearest power source, providing a utility island which eliminates jury rigging of power lines. Model PL 1044 (shown) contains 6 3-phase, 440-v receptacles, and 7 110/220-v outlets. *Mullenbach Division, Electric Machinery Manufacturing Company*.

Circle number (43) on reply card.

Continuous Integration Recorder

Electronic strip chart recorder with continuous integration measures, records, and continuously totalizes any linear variable with respect to time. It is designed primarily for gas chromatography analysis, but can be used to measure flow, continuous weighing systems, electric power line network consumption, and electric current in aluminum pot lines and other electrolytic cell lines. *Brown Instruments Division of Minneapolis-Honeywell Regulator Company*.

Circle number (44) on reply card.

Universal Joints

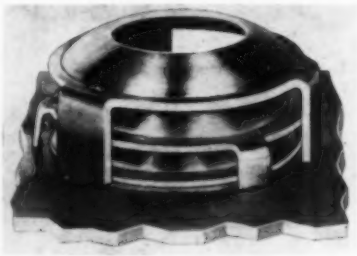
Bellows-type expansion joints accommodate pipe movement in any direction by absorbing axial movement, lateral deflection and angular rotation, singly or in any combination. Introduced by *Zallea Brothers*, the joints absorb unlimited amounts of lateral deflection without imposing any pressure thrust on piping or equipment, eliminating need for heavy structural anchors.

Circle number (45) on reply card.

Service Entrance Fitting

Made of aluminum, this cable head for 100-amp service installation is designed for easy wiring with plenty of turn radius. The unit has no loose parts, and is UL and CSA approved. One pressure screw holds the lid in place. Designed by *Killark Electric Manufacturing Company*.

Circle number (46) on reply card.



Fractionation Tray

Designed around a valve unit which acts as a variable orifice to provide multi-staging of the slot-area through various rates of vapor flow, the new ballast unit has established a higher efficiency than comparable trays. According to the manufacturer, *Fritz W. Glitsch & Sons, Inc.*, the ballast tray eliminates the problems met with conventional bubble cap trays and perforated trays.

Circle number (47) on reply card.

SEVERE LINE TESTS PROVE

CARBIDE COATED *CYCLONES*

SUCCESSFULLY COMBAT HIGH TEMPERATURE EROSION

• LONGER LIFE
• LESS WEAR
• LOWER MAINTENANCE
REDUCE REPLACEMENTS, maintenance and shut downs due to erosive deterioration and warpage.

Carbide Coating is a fused lining of carbide applied to the inside surfaces of Cyclones and pipe by precise automatic process. The dense carbide overlay effectively resists erosion at cracking temperatures. Carbide Coating also permits cyclone design improvement for more capacity and greater efficiency. Write or phone for full details.

BI-METAL PRODUCTS CO. INC.

7306 Bessemer • Cleveland 27, Ohio
BRoadway 1-1772

Division of the AMERICAN ALLOY CORPORATION
Cleveland 5, Ohio

Equipment

High-Vacuum Gage

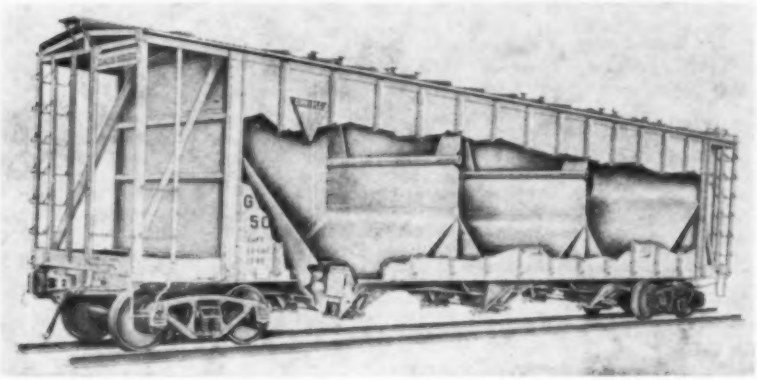
Incorporating the cold cathode principle, this gage tube operates safely at relatively high pressure and has extremely long life. Normal operating range of Model 100-A is 10^{-3} to 10^{-7} mm of Hg, according to *Miller Laboratories, Inc.*

Circle number (48) on reply card.

Anti-Static Work Clothes

Shirts, trousers, coveralls and lab coats are included in a new line of 100 percent Dynel work clothes, lightweight, antistatic and chemical resistant. Also, the clothes will not flash burn, and will stand up under hundreds of washings without color degredation. *Worklon, Inc.*, an affiliate of Mercantile Uniforms, Inc. has introduced the new line.

Circle number (49) on reply card.



Hopper Car Unveiled

Perfect sanitation for a variety of dry products ranging from foods to petrochemicals is assured by a covered hopper car developed by *General American Transportation Corporation*. With internal unloading gates, the "Dry Flo" cars provide freedom from contamination, ease of cleaning, greater rail clearance of the unloading gate outlets. The vertically opening unloading gates are unaffected by pressure or flow of the product being unloaded. The car can be emptied by vacuum or pressure pneumatic handling systems, gravity feed, or any mechanical system.

Circle number (50) on reply card.

PIPE LEAK REPAIR
— QUICK, FINAL!
ANY PRESSURE — ANY TEMPERATURE

SKINNER-SEAL EMERGENCY PIPE CLAMP for pinhole or corrosion leaks.

SKINNER-SEAL PIPE LINE CLAMP for long splits and bad corrosion leaks.

In stock — all supply stores

M. B. SKINNER COMPANY
SOUTH BEND 21, INDIANA, U. S. A.

Data-Gage Approved

A remote reading liquid level gage produced by *Texas Instruments Inc.* has been approved as accurate enough for auditing purposes by Sun Oil Company, following a test inventory audit. The Data-Gage system provides accurate readings of tank levels to the nearest sixteenth inch. Punched on paper tape, the information is then fed to a central computer to calculate tank volume.

Circle number (51) on reply card.

Molysulfide Added

Super HD Moly-Lith, an hydrogenated castor oil lithium grease with 3 percent Molybdenum Sulfide added, has been announced by *Frontier Refining Company*. Frontier is the first company west of the Mississippi to have the Molysulfide, which is noted for its affinity for metal. The grease won't work out, wipe out or wash out during the normal life of a grease job.

Circle number (52) on reply card.

Re-rated Vertical Motor

Totally-enclosed, fan-cooled, explosion-proof motor gives *General Electric Company* a complete line of vertical motors in the new NEMA re-rated frame sizes, from 7½ to 125 hp at 18 rpm. Designed for easier installation and maintenance in industrial pumping applications, this motor has oversize oil filler hole, large drain plug, easy access conduit box, oil level sight gate and lightweight top cap.

Circle number (53) on reply card.

RELIABILITY MEANS
IN MECHANICAL SEALING

DURA SEAL
The PERFECT SEAL
ROTATES WITH THE SHAFT

"THE ENGINEERED MECHANICAL SEAL"

because Dura Seal is backed by 25 years of experience — because Dura Seal is supported by continuous research for meeting modern processing demands — because Dura Seal is engineered to meet your specific operating conditions — because Dura Seal is nationally sold and serviced.

For Free Engineering Counsel on Your Sealing Problems, write DURAMETALLIC CORP., Kalamazoo, Michigan

Equipment and Literature

Additive Available For Lab Testing

Amounts of a non-metal-containing additive which promises to reduce static hazards are now available for developmental testing from the *Du Pont Company*. Known as SCA-100, the additive is ashless and compatible with other commonly used fuel additives.

Circle number (54) on reply card.

Stabilized Reagent

By packaging its single-solution reagent in 30 gal returnable aluminum drums, *Fisher Scientific Company* now offers the product at almost a 50 percent price reduction. Titration with the Karl Fisher reagent measures moisture specifically and in minutes, and permits determinations where volatility, oxidation or decomposition of samples prohibit use of ovens.

Circle number (55) on reply card.

Thermo-Siphon Fired Reboiler

New fired reboiler functions without hot oil pump. Instead, fluid circulation is maintained because of the difference in static heads of 100 percent liquid column and a hotter, partially vaporized column. Sizes from 500,000 to 3,500,000 Btu per hr can handle up to 40,000 lb per hr or 120 gal per min of hydrocarbon circulation. *Russell Engineering Corporation.*

Circle number (56) on reply card.

U-Bend Heat Exchanger Tube

New tube is manufactured in a choice of uniform gage, with thickened centers or with thickened ends, depending on specific requirements. Factory fabrication of U-bend tube eliminates handling and equipment costs for on-site bending, eliminates excess scrap, and handling and storage. Further information on standard and special sizes can be obtained from *Chase Brass & Copper Company.*

Circle number (57) on reply card.

King-Size Tanks

Believed to be the largest of their type in the world, two 223,000 bbl floating roof tanks store finished products at the largest refinery operated by Sinclair Refining Company. *Chicago Bridge & Iron Company* fabricated and erected the 200 ft diameter tanks, which are equipped with special Horton Type 5 floating roofs.

Circle number (58) on reply card.

Single-Unit Gage Valve

Designed to replace all conventional fittings and piping used to mount a gage and gage valve, the M5 Gage Manifold Valve is a compact barstock assembly. Inlet connection either ½ in. or ¾ in. NPT, outlets either ½ in. or ¼ in. female NPT. Rated at 5000 psig at 250 F. *Anderson Greenwood & Company.*

Circle number (59) on reply card.

Specifications on Ductile Steel

Full story of unique new cast metal that combines high strength and toughness with outstanding resistance to heat, wear and corrosion. Mechanical and physical properties, erosion and corrosion resistance, high temperature strength are given in tables and graphs. Booklet available from *The International Nickel Company, Inc.*

Circle number (60) on reply card.

Viscous Fluid Oil Heaters

Complete specifications and description of fuel oil heaters used on the suction side of pumps for heating extremely viscous fluids are given in an 8-page bulletin from *Brown Fintube Company*. Included are the tank suction type heater and the line type heater.

Circle number (61) on reply card.

Microfilm Reader Designed by Request

In answer to engineers' request for a microfilm reader with maximum readability and minimum maintenance, *The Filmsort Company* has introduced the Designer "184." Filmsort uses a new rare earth lens and a unique dual electrical switch system, which lengthens life of the projection lamp, to answer both requests. Information available in a booklet.

Circle number (62) on reply card.

Address: Dept. P-3

KERRIGAN IRON WORKS, INC. • NASHVILLE, TENNESSEE

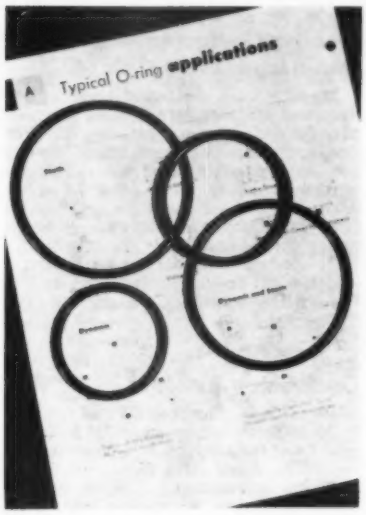
for leakproof, pressure-tight connections
use TiteSeal®
SEALING COMPOUNDS
Heat and vibration-proof, non-solvent, will not shrink, crack or crumble. Makes all assemblies leak-proof and pressure-tight. Prevents rust, corrosion, joint seizure.
BRUSH-ON
7 BASIC BLENDS
LIQUID WRENCH®
The super-penetrating rust solvent
LOOSENS
rusted bolts, nuts, screws, 'frozen' parts
Liquid Wrench works fast...yet is absolutely safe for all metals and alloys.
2171
At Industrial, Automotive, Hardware, Plumbing Jobbers
RADIATOR SPECIALTY CO.
Charlotte, North Carolina
SOLDER SEAL

New Literature

Plastic Piping Systems

Technology of plastic piping systems, including plastics used, installation and coupling methods, standard temperature and working pressure chart for valves, plus a table showing effects of 280 chemicals on 5 plastics, is described in a handbook offered by *Chemtrol*.

Circle number (63) on reply card.



"O" Ring Booklet

Design and application of "O" rings, including materials of construction, dynamic and static applications, use of back-up or non-extrusion rings, and groove design, has been published by *The Garlock Packing Company*.

Circle number (64) on reply card.

TV Cameras for Industry

Complete specifications for two TV cameras designed for industrial use are included in a bulletin from *Cohu Electronics*. Models covered are the Model 1986C, standard unit used in most closed-circuit applications, and the Model 1986CN, specified when extreme noise levels are a hazard.

Circle number (65) on reply card.

Additive Blender Control Systems

Automatic proportioning of liquid dyes, solvent oils and other petroleum additives to gasolines or fuel oil streams is done by a metering-type additive blender, described in a bulletin issued by *B-I-F Industries, Inc.*

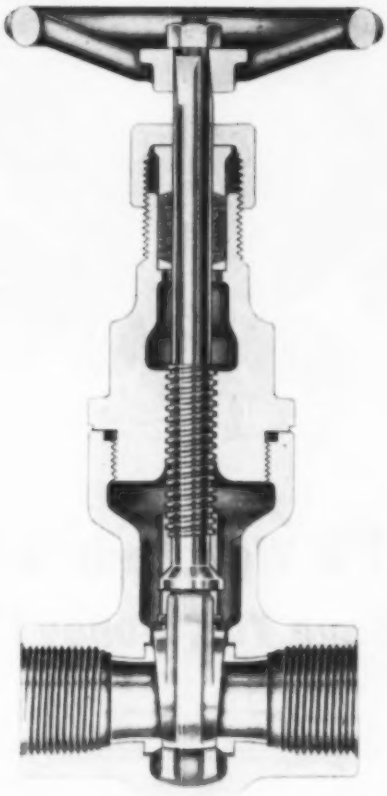
Circle number (66) on reply card.

Aluminum Usage for Heat-Exchangers

Technical information needed by the heating engineer, fabricator and industrial purchaser on the advantages of aluminum in heat-exchanger fabrication is presented in a new publication from *Reynolds Metals Company*.

Circle number (67) on reply card.

Corrosion Equalizer . . .



Designed for dependability . . . Engineered for economy Pacific's 150 lb. Stainless Steel Gate Valve, Fig. No. S-555, is ideally suited to an assortment of corrosive low temperature, low pressure service applications. Hexagon shaped body ends facilitate easy service and installation. Straight through ports offer minimum flow restrictions. Solid one-piece wedge is ground and lapped to 6 micro-inch finish for uniform bubble tight seating contact. Valve stem with long acme threads promises ease of operation. Re-inforced stem and wedge connection provides for additional strength at T-head.

Modestly priced and thoughtfully designed the S-555 is available in sizes ¼" to 2". Timesaving service from warehouse stock assures you of prompt delivery to meet your immediate needs.

Lifting wedge with seat ring when two are "wrun" together using a light lubricant, typifies perfect surface contact seal.

Brochure available. Write today for yours.

PACIFIC VALVES, INC.

3201 Walnut Ave. Long Beach 7, Calif.

Sales Offices in Most Principal Cities

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

LENAPE Weld Ends & Rings
Save You Money!

Cost conscious designers and fabricators are taking advantage of the inherent economy of Lenape forged rings and weld end connections. Specialized production techniques permit seamless forging of most alloys, including stainless—and at lower cost than other methods. Connections and manway rings are manufactured to customer specifications, and are normally furnished ready for attachment without further machining or necessity of additional reinforcement, an obvious saving in time and labor.

Lenape weld ends and rings, such as those illustrated, are widely used for nuclear power reactors, high pressure steam generators, catapult accumulators and many other modern constructions.

Find out how Lenape can save you money on your pressure vessel connections. Write for information.

See our standard line of pressure vessel connections on pages 1128-1129 in the 1958 Chemical Engineering Catalog.

LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 119 WEST CHESTER, PA.
RED MAN PRODUCTS

New Literature

Nickel Alloy Wire Cloths

Range of weaves and sizes of nickel alloy wire cloths available for various purposes are described in a 15-page booklet from *The International Nickel Company, Inc.* Mechanical properties of "A" nickel, Monel nickel-copper alloy, Iconel nickel-chromium alloy, and Incoloy iron-nickel alloy are given, including examples and case histories.

Circle number (68) on reply card.

Pressure Reducing Valve Introduced in Pamphlet

Made from a semi-steel body with a hardened stainless steel valve seat, the new "RVA" pressure reducing valve is designed to control steam, water, air and non-toxic, non-flammable gases. The diaphragm-actuated, direct-acting valves reduce pressure automatically and hold a constant reduction despite changes in the high-pressure line. They are suitable for initial pressures up to 250 psi at 450 F and 300 psi at 200 F. Produced by *The Clark Manufacturing Company.*

Circle number (69) on reply card.

Gearmotor Bulletin

Right angle gearmotors, rated from ⅓ to 30 hp, with output speeds of 23 to 280 rpm, are featured in a 4-page bulletin from *The Louis Allis Company.* Flange mounting arrangements available with the single reduction gearmotors are given, plus engineering specifications.

Circle number (70) on reply card.

Heaters Presented

Ross Instantaneous Heaters with extra-large steam inlet area are presented in a booklet released by *American-Standard.* Principal features include unique location of steam inlet, construction, design, copper alloy U-tubes and removable, pull-through tube bundles. Selection tables, charts and piping diagrams are provided to aid selection of proper units for various requirements.

Circle number (71) on reply card.

Acid Valves Shown

Aloyco 20, special austenitic stainless steel recommended for valving sulfuric acid and other corrosive liquids, is described in a technical bulletin from *Alloy Steel Products Company, Inc.* Strengths and temperatures of sulfuric acid in which the alloy may be used are shown by graph.

Circle number (72) on reply card.

Thermostat Described

An explosion proof thermostat designed for convenient immersion in tanks, wall installation and for exposure to contaminated environments has been announced by *Fenwall Incorporated.* Current rating is 10 amps 115 VAC, or 5 amps 230 VAC.

Circle number (73) on reply card.

Metering Pumps Debut

Four newly-designed metering pumps designed for proportioning performance and economy, are described in a bulletin from *Hills-McCanna Company.*

Circle number (74) on reply card.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

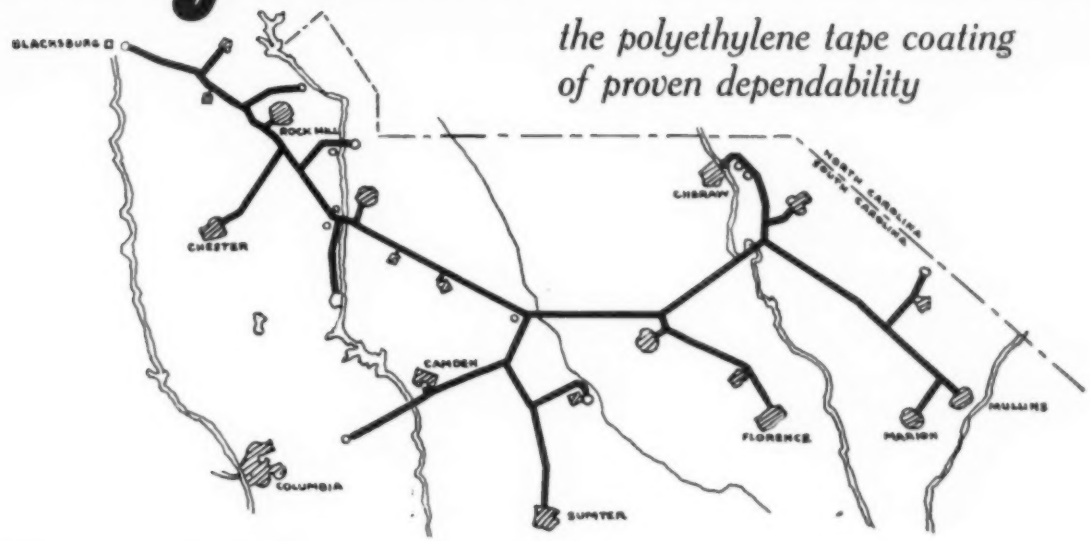
PIPELINE Engineer

Pipeline Corrosion Report

New Carolina pipeline uses

Polyken Protection

the polyethylene tape coating of proven dependability



The contractors—Panama Williams Corporation and Buchanan Contracting Company used Polyken Tape for its construction savings in time, labor and handling costs.

Fewer delays with Polyken
Pipe can be lowered directly into the ditch after being wrapped. (Scene near Rock Hill, S.C.)

Combination cleaning and wrapping
Clean pipe is ready to be wrapped immediately. No wasted manpower here.

The Carolina pipeline system—serving ¼ of the entire state of South Carolina—will bring natural gas to one of the most important industrial regions of the South.

Polyken polyethylene tape was chosen as the coating for this system because it's proven.

Pipeline operators have seen how polyethylene stands up to the corrosive combination of moisture, soil chemicals and electrolytic current.

And contractors have found that The Polyken Method provides cost-cutting advantages like these:

1. **Substantial labor and equipment savings because of simplified operation.**
2. **Faster construction—consistent high daily output.**
3. **No hot dope preparation—tape is always ready.**
4. **No drying or cooling time. Simple clean-wrap-and-lower operation makes for a tight spread and closer supervision.**
5. **Vastly reduced warehousing, shipping, handling costs.**
6. **Liabilities virtually eliminated—no fumes, no burns, no need to worry about human and livestock hazards.**
7. **Wrap goes into ground in factory-uniform condition.**

If you would like to know more about this time-saving, time-tested coating, contact Polyken Sales Division, Dept. PE-3, 309 W. Jackson Blvd., Chicago 6, Ill.

Polyken®

Experienced in modern PROTECTIVE COATING

THE KENDALL COMPANY
Polyken Sales Division

TELETAX* TELEMETERING

by Foxboro...

engineered for the most advanced transmission techniques

Telemetering matched in performance with famous Foxboro instruments — that's the Foxboro Teletax Telemetering System.

Through use of impulse-duration signals, Teletax electrically transmits measurements of a remotely-located variable to the central control station. Here, the Teletax receiver records the duration of impulse, which is directly proportional to the measured variable.

The Foxboro Teletax System is noted for its simplicity, its versatility, and its high sustained accuracy. For a transmission medium, it can use either AC or DC, an audio frequency carried on a transmission line, or radio or microwave impulses. Sustained accuracy is 0.5% of full scale.

TELETAX RECEIVERS

Teletax receivers include: Single or Dual Receivers; Multi-Record Receivers for recording up to 6 separate measurements on one chart; and Teletax Receiver-Controllers for automatic operation. And the Teletax signal can be simply converted to digital information.

TRANSMISSION LINK

With Foxboro's Teletax Telemetering System, you can use the most advanced transmitting techniques: two wire lines, power lines, radio or microwave. As many as 25 different signals can be handled in each direction, simultaneously.

TELETAX TRANSMITTER

The Teletax Transmitter houses either one or two standard Foxboro measuring elements — plus the Teletax transmitting mechanism. It will transmit to a control center hundreds of miles away just as easily as to one nearby. It also indicates or records locally if desired.

The Teletax Transmitter needs no periodic maintenance whatever, while the receiver requires only occasional oiling. And the receiver has a minimum of mechanical components to wear — no clutch to slip or jam.

Foxboro Teletax Systems are now in wide use on natural gas systems, water works, oil fields, power plants, steel mills, etc. Write for Bulletin 17-11C — it gives all the details. **The Foxboro Company, 383 Norfolk Street, Foxboro, Mass.**

Reg. U. S. Pat. Off.

FOXBORO
REG. U.S. PAT. OFF.
TELETAX TELEMETERING

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Polyken Sales Division

PERFORMANCE speaks louder and clearer than the words of any language. You can believe what you see! Crose is a magic word in far off lands. It's a word that bridges the gap between language and custom, because on pipeline construction equipment Crose not only stands for but also demonstrates top performance under roughest, toughest conditions.

FOR THE BEST, USE CROSE — ANYWHERE!

WORLD

LEADER IN PIPELINE

CONSTRUCTION

EQUIPMENT

Crose MANUFACTURING COMPANY, INC.
2765 DAWSON ROAD PHONE WEBSTER 6-2171
TULSA, OKLAHOMA • BRANCH OFFICES: HOUSTON • DENVER • ELIZABETH, N. J. • IN CANADA: CROSE-CURRAN LTD., EDMONTON, ALBERTA

This pipeline man wanted to know:

WILL A BELL SAVE ME MONEY?

At some point, most pipeliners take a long look at their ordinary equipment and the thought comes to mind: What about a helicopter? In the case of this Oklahoma construction company, the boss was looking, also, at a contract just signed . . one calling for a 30-inch gas line across 343 miles of mountains in Alabama, Tennessee and Kentucky.

What the company did was *charter* a Bell. From there on, discovery followed discovery. On the first day out, after spotting a broken-down bulldozer, the Bell flew in mechanics and parts for quick repair. Then it started shuttling spread-superintendents to work sites, helping engineers keep track of progress, jumping here and there to haul in a tool or bring out an ailing workman. Just its hovering presence gave the entire job the feel of being under control.

This Oklahoma company now uses a Bell on four other spreads, in such new-found ways as hunting out roads, ferrying survey crews, flying in inspectors and personnel. How about the value of a Bell in your own operation? Charter is a low-cost way to find out. We'll be glad to send you names of Charter Services in your area, along with additional information on Bell models and other convenient ways to try the Bell. Simply write Dept. 35C, Bell Helicopter Corporation, Fort Worth, Texas.

BELL Helicopter CORPORATION

FORT WORTH, TEXAS

SUBSIDIARY OF BELL AIRCRAFT CORPORATION

Proved outstanding under every digging condition, here the new Model 774 digs 5½-foot-deep trench through Texas "Gumbo."

NEW DUAL-HYDRAULIC* SPOIL CONVEYOR

Provides full range of belt speeds at all wheel speeds . . . under any condition

The new dual-hydraulic spoil conveyor is just one of the many new, exclusive features which enable the all-new Barber-Greene Model 774 to dig up to 25% more ditch per day. It offers you these unmatched advantages:

All-hydraulic drive utilizes separate hydraulic motor at each end of conveyor . . . eliminates all drive sprockets, chains and mechanical transmission.

Independent conveyor drive divorces conveyor speed from both wheel and crowding speeds.

Instant speed selection while operating. Speeds infinitely variable to 640 fpm. Instant reverse.

New rubber impact rollers eliminate shaft bending and greatly reduce material build-up for greater belt life.

Fully enclosed design reduces maintenance costs by further reducing material build-up under belt.

Optional 2-foot extension available for special soil conditions and wide cutting widths—folds to 8-foot width for travel.

*Hydraulic motors drive spoil conveyor from both ends regardless of belt direction. Write for 16-page booklet on this new ditcher.

All the new, exclusive Model 774 advantages add up to fastest, lowest-cost trenching

• Dual-Range Hydra-Crowd • New Digging Wheel Drive • New Flexible Drawbar • New Hydraulic Controls • New Crawler Design • New Automatic Overload Protection • New Hydraulic Brakes • New Hydraulic Boom Hoist

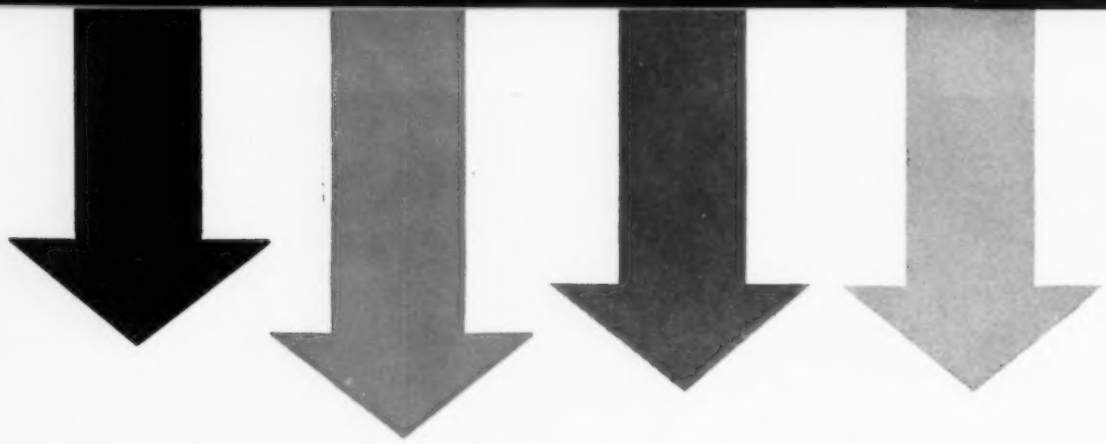
Write for information on the ditcher line of advanced design.

58-27-D

Barber-Greene BG

AURORA, ILLINOIS, U.S.A.

CONVEYORS . . . LOADERS . . . DITCHERS . . . ASPHALT PAVING EQUIPMENT



When you need cathodic protection for underground structures it's the high silicon iron, DURIRON, that counts!

IN ALL ORDINARY CASES . . . DURIRON IS JUST AS GOOD AS GRAPHITE; AND IN THE REALLY TOUGH CASES, DURIRON ANODES ARE BETTER

1. Unexcelled corrosion resistance
2. Good electrical properties
3. No current density limitations
4. No undesirable corrosion products
5. Easy to install

STANDARD DURIRON ANODE SIZES

Type Anode	Size	Area Sq. Ft.	Weight (Lbs.)	General Application
B	1" x 60"	1.4	14	Fresh Water
C*	1½" x 60"	2.0	25	Ground Bed
D	2" x 60"	2.6	46	Ground Bed
E	3" x 60"	4.0	115	Salt Water
G	2" x 9"	0.4	5	Ducts
J	3" x 36"	2.5	80	Salt Water
M	2" x 60"	2.8	57	Salt Water

* Applicable also in fresh water service. Should not be used in ground beds without backfill.

Go all the way with the high silicon iron, Duriron*. Its superiority in marshlands, at river crossings, and wherever backfilling is impractical or imperfect has been proved without question. And in all perfect backfill cases (where the anode is merely the conducting rod) Duriron serves exactly the same purpose as graphite, and just as well.

Duriron anodes have proven their superiority for the cathodic protection of pipelines, drilling rigs, well casings, storage tanks, gathering lines, communications cables, and similar systems. For positive protection, insist on DURIRON.

* *For high chloride environments, The Duriron Company manufactures the molybdenum containing high silicon iron, Durichlor.*

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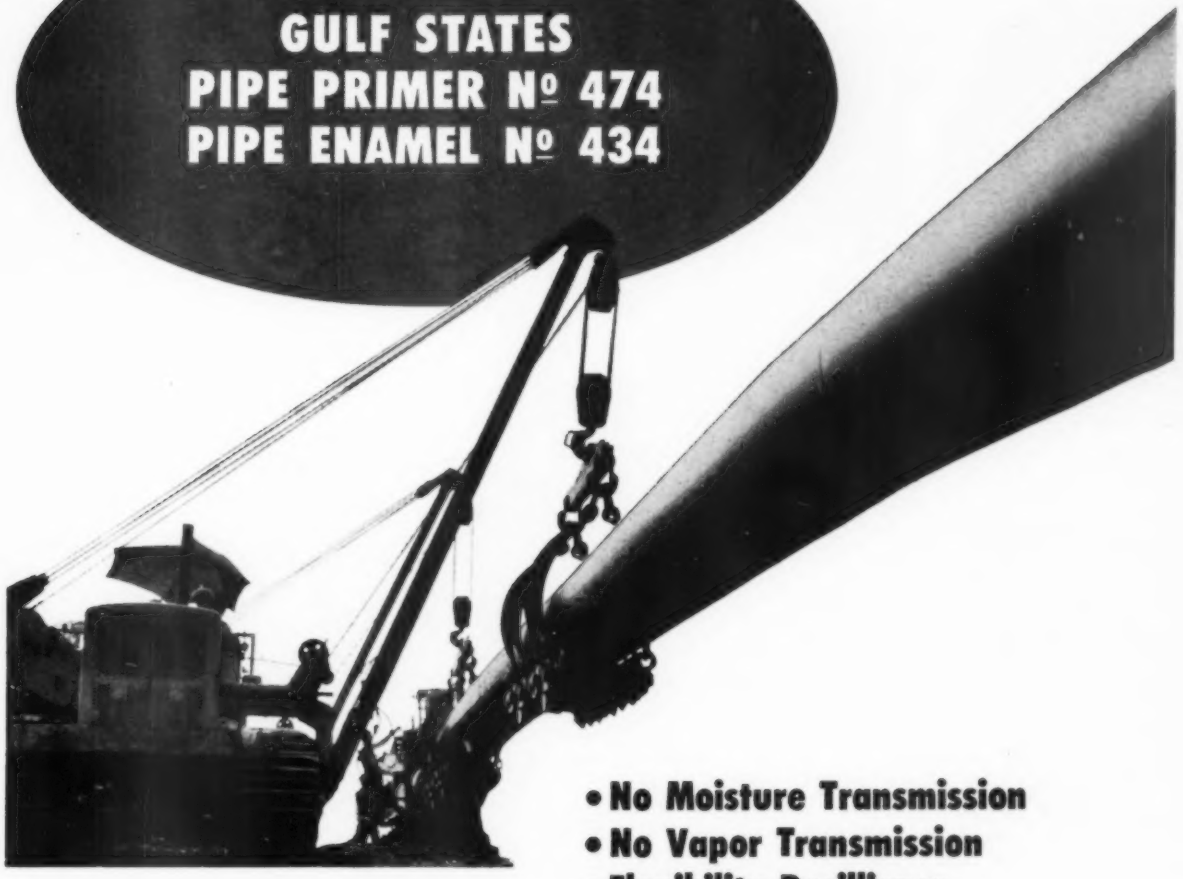
DURCO

GULF STATES
PIPE PRIMER Nº 474
PIPE ENAMEL Nº 434



- No Moisture Transmission
- No Vapor Transmission
- Flexibility Resilliency
- Soil Stress Resistance
- Heat Stability
- High Electrical Resistivity
- High Temperature Performance
- Primer Efficiency
- Negligible Soluble Salt Content
- No Obnoxious Fumes

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City and State_____

Near the line's western terminus, at an altitude of 2700 ft, crews are shown actually laying pipe down into a cloud bank.

There was rough terrain along the entire route of the Leidy Line. Grades of 40 pct and more were frequently encountered.

Contractor for Spread A, 65.53 mi, was Sharman, Allen, Gay & Taylor, Inc.; contractor for Spreads B (45.98 mi) and C (52.33 mi) was Panama-Williams Corp.

Working above the clouds on Transco's high-test line

There's some mighty rugged country in Pennsylvania, none of it tougher for pipe laying than along the route of Transco's Leidy Line. There, in the northern and eastern sections of the state, the Appalachian Mountains thrust their sharp ridges high above the valleys. For crews laying 24-in. Bethlehem line pipe, this meant working on severe grades, frequently up to 40 pct, and at altitudes ranging from 900 to 2700 ft. There's hardly a level stretch on the entire 164-mile length of the line. In addition, there are numerous crossings of rivers, streams, highways, and railroad rights-of-way.

Completed in December, the Leidy Line connects Transco's main line (McAllen, Texas, to New York City) with a newly developed storage field near Renovo, Pa. There, worked-out gas wells provide underground storage capacity. This functions as a "bank" where Transco customers can deposit gas during slack periods for withdrawal to supply peak load requirements.

All of the API pipe laid from the Delaware River to the storage field was supplied by Bethlehem from our Steelton, Pa., fabricated pipe shop.

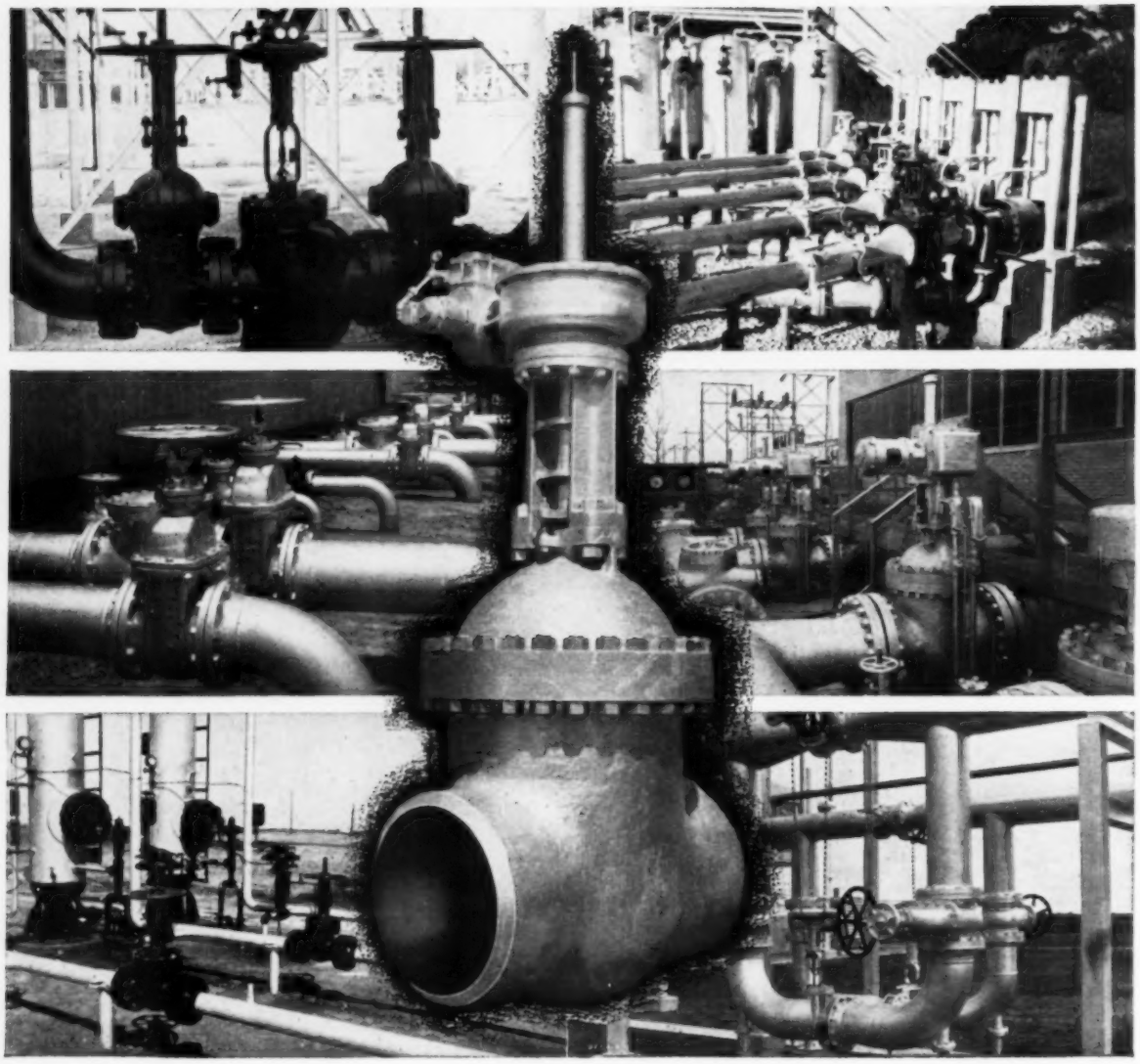
Line Pipe to 42 in. OD. At Steelton we are equipped to produce API pipe, hydraulically expanded, in all diameters from 18 in. to 42 in. OD, the latter with walls to ¾ in. Electric resistance-weld pipe from 5½-in. to 16-in. OD, and continuous buttweld pipe from ½-in. to 4-in., nominal, are produced to standard API line pipe specifications on our Sparrows Point, Md., pipe mills.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL



Unmatched advantages whatever the service . . . with

Darling Fully Revolving Double Disc Parallel Seat Gate Valves

ALL the Darling gate valves shown here, from the large 30″ main line valve to small 4″ loading pump valves share identical multiple advantages. They operate with the positive yet easy closure . . . the uniform wear distribution . . . the elimination of disc-to-seat galling . . . the adjustment for valve body distortion . . . the minimum, simplified maintenance and the extended, trouble-free service life made possible by the well-proved fully revolving double disc gate principle perfected by Darling.

Why not check into Darling gate valves for your next requirements? Find out *how* they assure all these advantages . . . and let us give you proof! Write for Catalog No. 57.

DARLING VALVE & MANUFACTURING CO.

Williamsport 2, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ontario

DARLING VALVES

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LIMA Paymaster Pullshovel equipped with a 20-ft. boom and ½-yd. bucket on trenching job near Tulsa, Okla.

Let the rugged LIMA Paymaster speed your pipeline trenching

When it comes to trenching under adverse conditions, more and more pipeliners are finding that nothing beats a LIMA Paymaster for profit-making operation. Regardless of the type of footing, the LIMA Paymaster works at top speed through long hours and without costly downtime. The Paymaster has the built-in quality and endurance to keep your digging jobs ahead of schedule. Its ease of control assures accurate trench specifications. Long wide crawlers provide outstanding stability in soft ground. Piston-ring-type dirt seals and retainers in crawler rollers seal in lubricant and exclude dirt and sand that wear out bushings and shafts. Moving parts are flame or induction hardened for longer life. Shafts, drums and other moving parts rotate on anti-friction bearings. Propel and swing gears and power take-off are enclosed in a sealed oil bath. These are a few of the many quality features found in LIMA shovels (½ to 6 cu. yds.), pullshovels (½ to 2½ cu. yds.), cranes (to 110 tons) and draglines (variable).

Why not let high-output LIMAS work for you? Have your nearby LIMA distributor tell you what LIMA pullshovels and cranes will mean on your pipeline operation. Or write Construction Equipment Division, Baldwin-Lima-Hamilton Corporation, Lima, Ohio.

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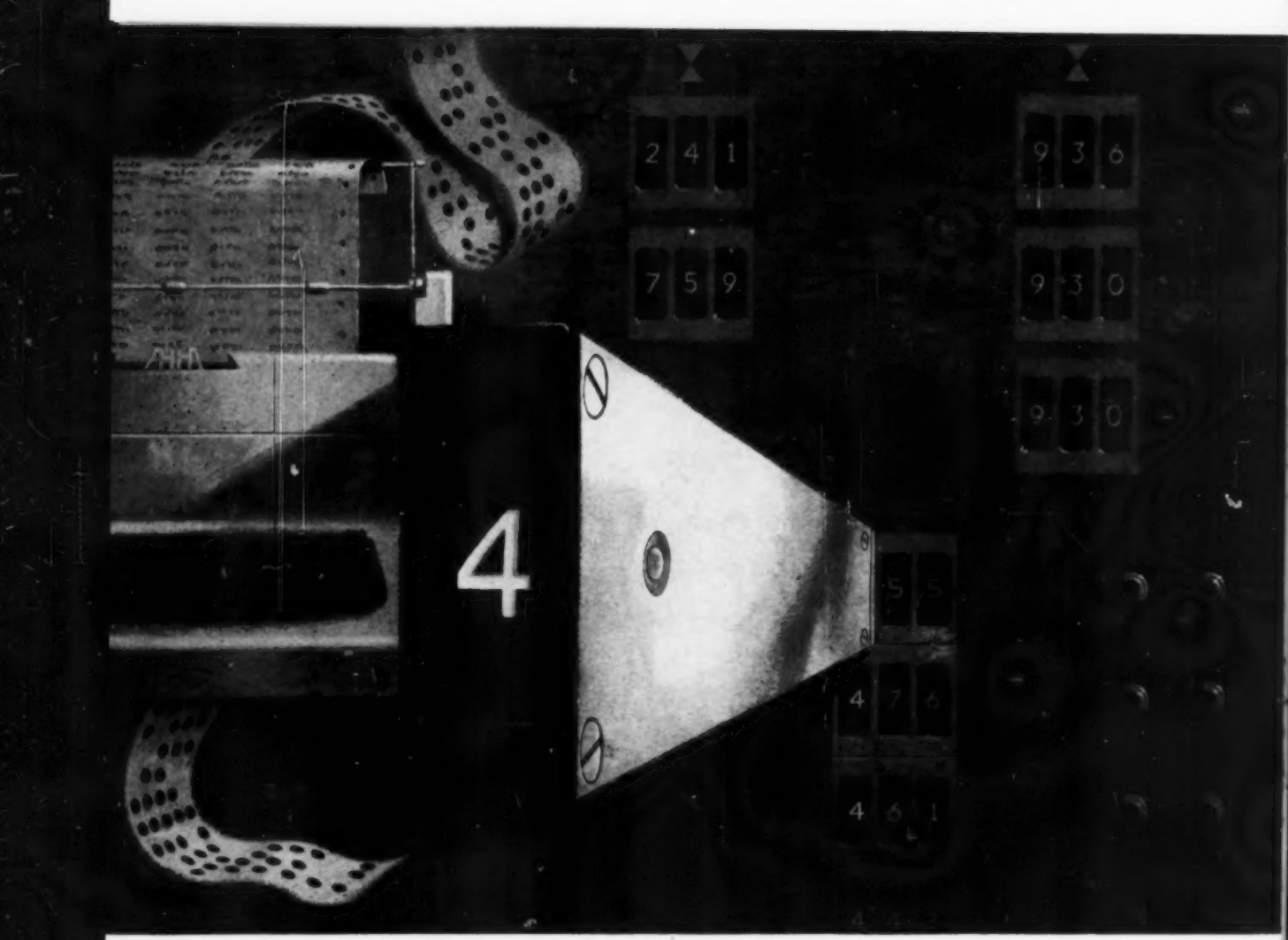

NEW CONTROL CONCEPT
can cut your pipeline costs

Did you ever try to solve a jigsaw puzzle without first looking at the total picture the puzzle makes? Pretty difficult—maybe even impossible. Best way, easiest way is to look at the big picture first, then see where the individual pieces fit.

It's the same with pipeline control.

First, look at your total system problem. Then, determine what sort of control system is required to safely, reliably and economically meet tomorrow's need as well as today's. That is Union Switch & Signal's approach to pipeline control.

Any part of a pipeline system. Union Switch & Signal can incorporate in a centralized control system any or all of the following functions: supervisory or remote control of satellite stations . . . telemetering of flow data from field back to your central dispatching office . . . automatic sequencing or control of equipment in the field . . . instrumentation . . . data handling and display . . . computing equipment . . . automatic integration of field data into your accounting operations . . . communications. Union Centralized Transport Control can be adapted to *any* problem from remote control of a single-unit booster station for gas or oil to automatic centralized control of an entire system from wellhead to ultimate consumer.

Error-free. Whatever the job assigned to it, Union Centralized Control operates completely free from error because it reduces to coded digital form all information and instructions transmitted to or from your central control office. As a result, you can transmit far more precise data than ever before; you can use the least expensive available communications service; and you never need to worry about lightning, noise or other interference causing a wrong or dangerous operation—this coded system automatically checks itself and responds *only* to correct and logical signals. It helps make your pipeline safer. It provides error-free *security* as well as reliability.

Lower operating cost. Most important, Union Centralized Transport Control cuts your operating costs, cuts the cost of future expansion, sometimes even cuts present installation cost of pumping stations.

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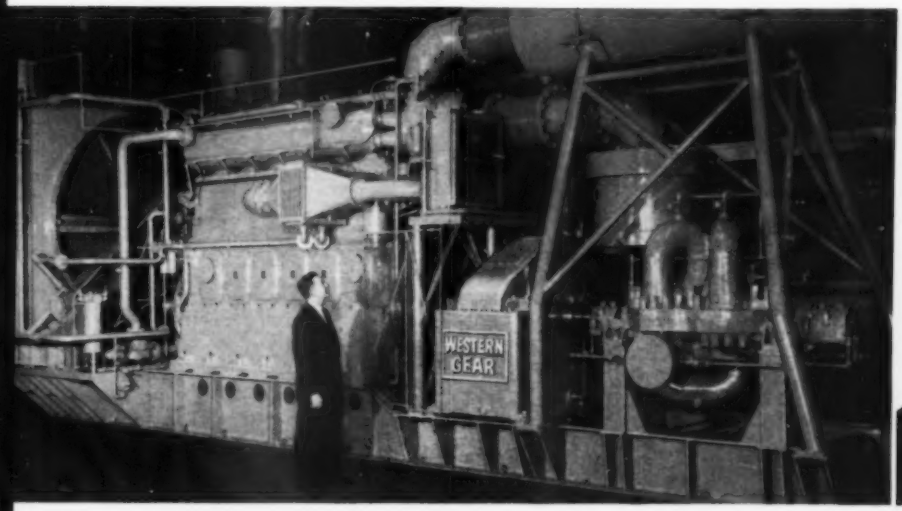
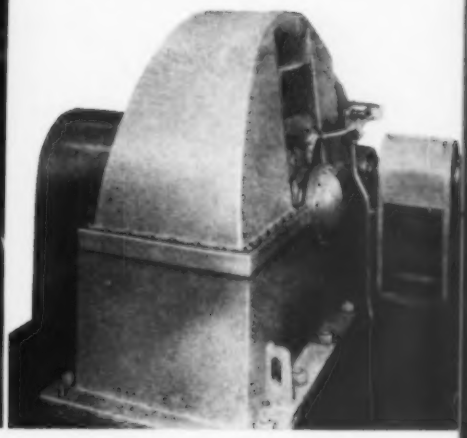
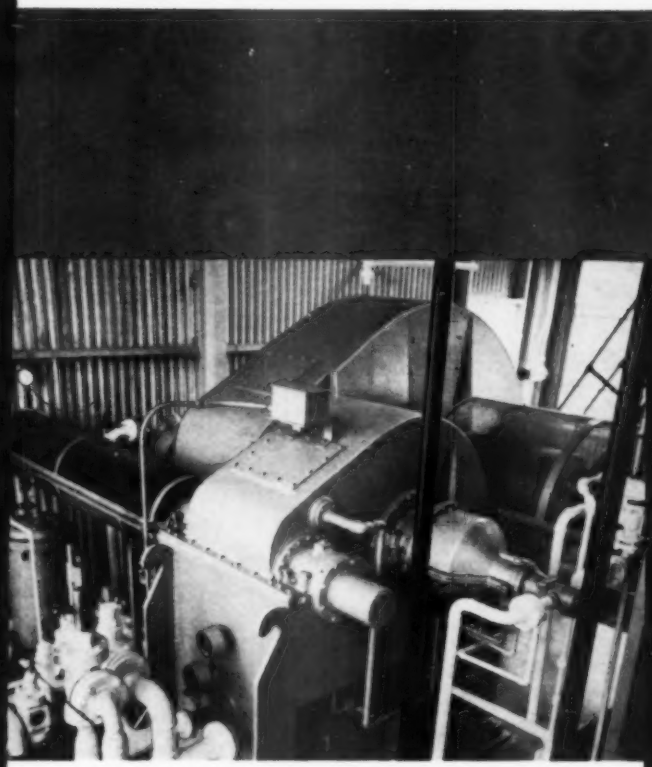




WESTERN GEAR DRIVES MORE CRUDE, REFINED PRODUCTS AND GAS

under toughest performance requirements



Western Gear engineers designed to order this two-stage high speed gear drive to step up the 5000 HP natural gas-operated 16 cylinder Cooper-Bessemer engine to power a centrifugal compressor at 6,055 RPM.

From Kentucky to Kuwait, Western Gear pipeline drives are pushing record volumes of crude oil, refined oil and natural gas.

Upper left illustrates one of four portable pumping units built by Enterprise Engine and Machinery Company to pump oil for American Independent Oil Company in Kuwait, Arabia. The Western Gear high speed drive boosts a 600 RPM input to 3550 RPM output at 4 points along the 35 mile bleak desert pipeline route.

Upper right photo shows one of the Western Gear pipeline speed increasers, largest in the U.S., used on Mid-Valley's 1,000 mile crude oil pipeline. And at the left is pictured one of 21 Western Gear high speed drives used to push 575 million cubic feet of natural gas daily through the 845 mile, 30-inch main pipeline of Gulf-Interstate Gas Company.

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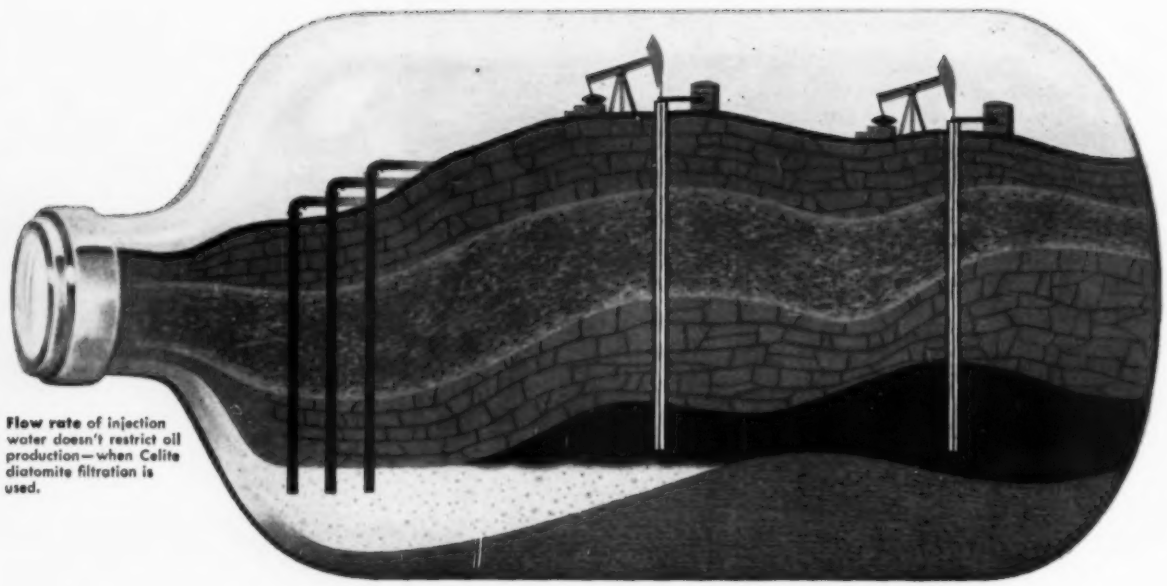


Flow rate of injection water doesn't restrict oil production—when Celite diatomite filtration is used.

No more *bottlenecks* in the formation pores!

Celite diatomite filtration removes all pore-clogging solids from injection water... permits fastest flow rates

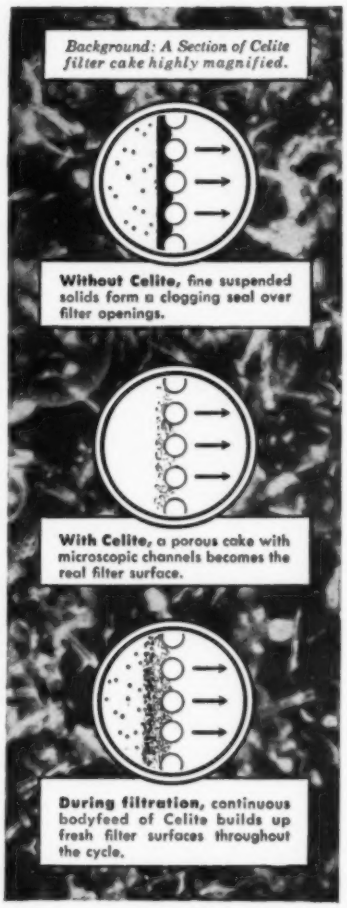
NOW YOU CAN PREVENT the build-up of suspended solids that sharply reduces injection water flow and oil output. J-M Celite filter aids take *all* clogging corrosive solids out of the water before they can get into the well.

Every cubic inch of Celite presents over 2.5 million microscopic filter channels for the water to pass through. These channels remove all corrosive products including oil, amoebae and most bacteria that plug injection wells. This results in sparkling clear water, maximum flow rate into the formation at lower pressures, and long uninterrupted periods of operation. A Celite filter unit requires 10 times less space than other types of filtration, is simply and easily cleaned and back on the line in a hurry.

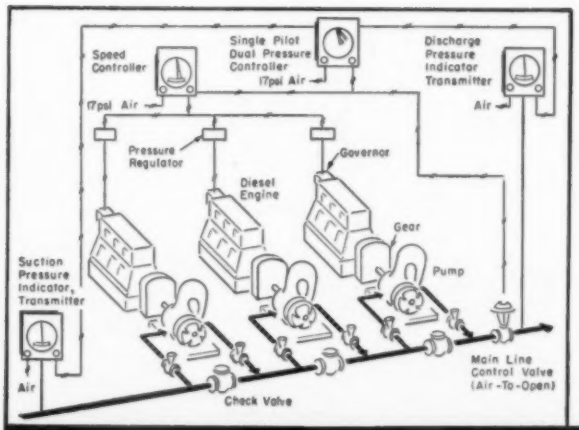
Specially processed from the world's largest and purest commercially available deposit of diatomaceous silica, Celite is your best assurance of years of trouble-free filter operation. Nine standard grades have been developed to meet all filtration needs; you can pick the one that suits your system best. And when you reorder, you'll find that each grade of Celite remains constantly uniform.

A Celite engineer will be glad to help you set up a workable filtration system and recommend the proper grade of Celite powder for your needs. Write: Johns-Manville, Box 14, New York 16, N.Y. In Canada: Port Credit, Ontario.

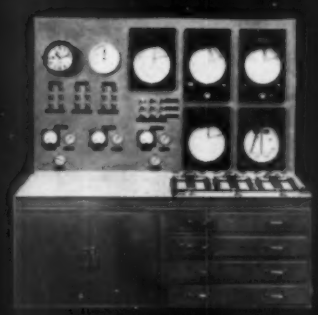
*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.


Background: A Section of Celite filter cake highly magnified.
Without Celite, fine suspended solids form a clogging seal over filter openings.
With Celite, a porous cake with microscopic channels becomes the real filter surface.
During filtration, continuous bodyfeed of Celite builds up fresh filter surfaces throughout the cycle.

JOHNS-MANVILLE JOHNS-MANVILLE JM PRODUCTS



▲ Honeywell controls automatically balance suction and discharge pressures at each of six pumping stations. If the suction or discharge pressure deviates from the set limits, the pipeline is automatically protected in two ways. The decreasing pressure output from the single-pilot dual pressure controller lets the valve close . . . causes the speed controller to slow down the engines if the decreasing signal drops below the speed controller set point.



▲ Pumping stations No. 1 through No. 5 have Honeywell control consoles with graphic panels. In addition to the necessary temperature, pressure, flow and speed recorders and controllers, each console contains a complete alarm system to protect workers and equipment.

▲ The use of standard off-the-shelf instruments on this control console for Station No. 6 and the other five consoles simplifies maintenance . . . gives the flexibility needed for easy expansion.

U. S. planes in Spain fueled by 485-mile pipeline

Line is automatically controlled by Honeywell instrumentation

A pipeline that extends almost the full length of the Spanish peninsula carries jet fuel and aviation gas to U.S. Air Force bases. Honeywell instrumentation serves four basic functions in the line: running control, measurement, safety, and start-stop control.

The six diesel-powered pumping stations that keep fuel flowing are equipped with semi-automatic starting and automatic running and stopping control. A graphic console is the control center for each station.

Throughout the entire system, design emphasis is on standard, off-the-shelf equipment and minimum maintenance—in keeping with military requirements. And while the system is quite simple in comparison with the more highly sophisticated remotely-controlled pipelines in service today, it provides the maximum in automatic, economical control. Moreover, its extreme flexibility allows for simple expansion.

Honeywell, world's largest maker of controls, is the logical source for your own instrumentation needs. Call your nearby Honeywell field engineer today . . . he's as near as your phone.

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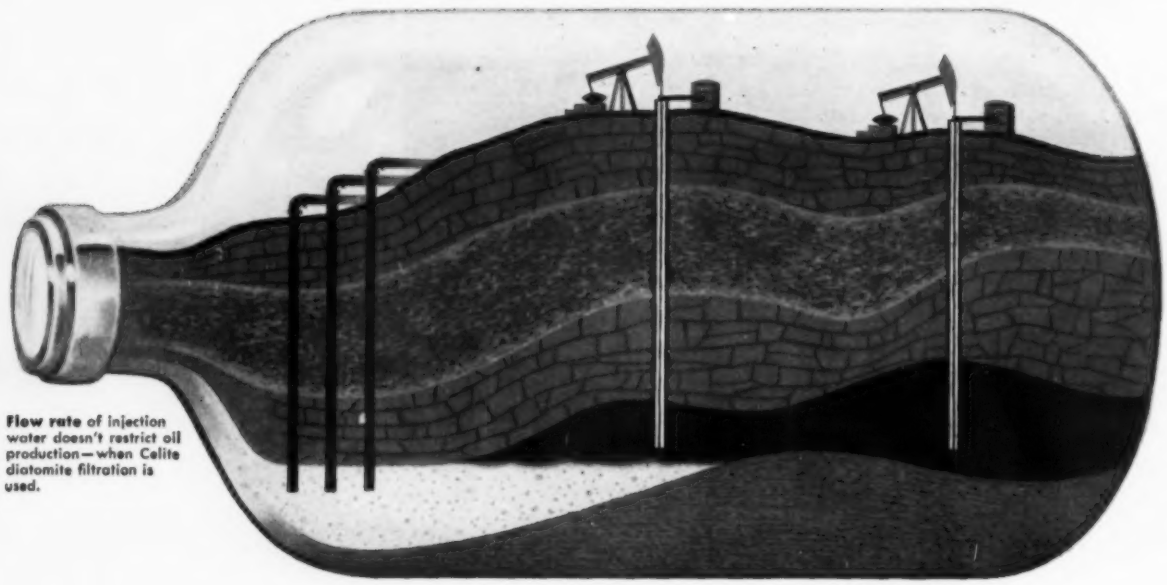

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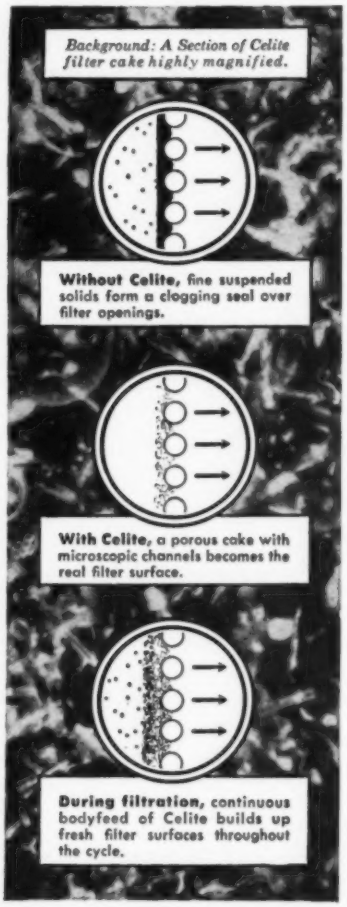
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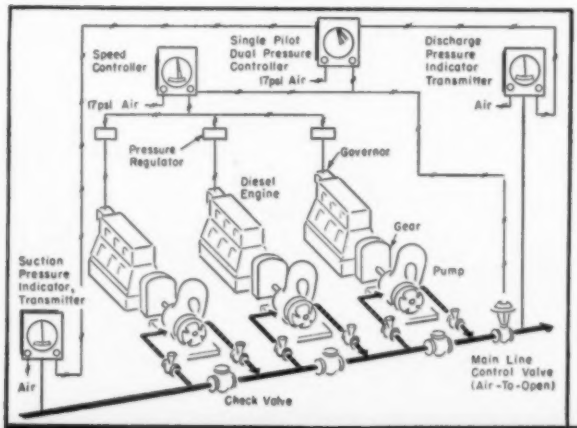
JOHNS-MANVILLE JOHNS-MANVILLE JM PRODUCTS



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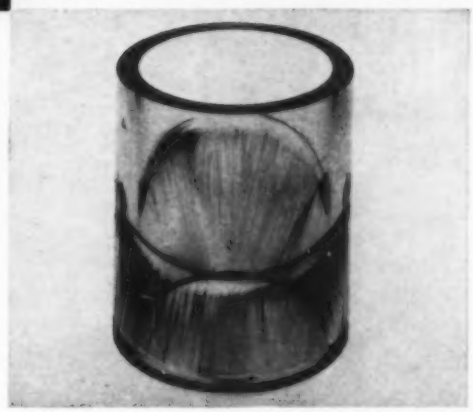
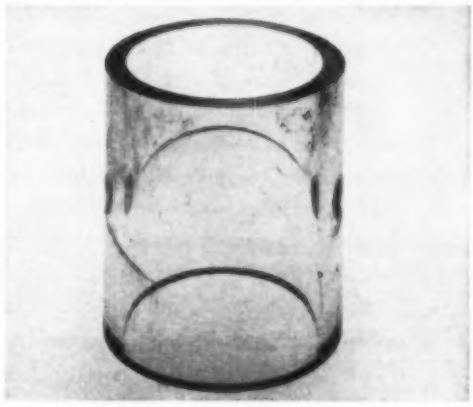
The three photos on the right were taken of glass throttle bodies at the conclusion of a carburetor cleanliness test in which the additives, at low anti-icing dosages, were compared on an equal cost basis.



No additive

Best competitive detergent additive



Unicor-LHS

Sure-fire prevention of carburetor icing—*plus* positive prevention of carburetor clogging! That's what you give your customers when you safeguard your gasoline by adding Unicor-LHS.

In addition to its well-known anti-icing and corrosion-protective characteristics, Unicor-LHS provides ideal detergency action. Recent tests at Universal's laboratories (see photos at right) demonstrate that Unicor-LHS imparts greater detergency to your fuel than the best competing additives.

Convenient and economical to use, this anti-icing additive can be introduced anywhere—refinery, bulk plant or filling station—at less than half the cost of ordinary anti-icers.

We shall be glad to determine the exact anti-icing and carburetor detergency requirements of your fuels.

For detailed information, samples, or commercial quantities, write to our Products Department.

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Motorola Microwave controls offshore oil production

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Today in hundreds of inland drilling, pipeline and refinery operations, dependable Motorola microwave is used to read gages . . . to open and close valves . . . to start and stop motors . . . in addition to carrying voice and printed messages to and from centralized control centers. All this at the lowest per mile operating and maintenance cost.

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CORROSION REPORT

Plan Protection When Designing System

What is done or not done before pipeline is built will mean the saving or wasting of thousands of dollars

Marshall E. Parker, *Consulting Corrosion Engineer*

BEST TIME to start planning a corrosion control program for a major pipeline system is while the system itself is in the planning stage.

True, a cathodic protection system cannot be designed at that time, but its design will be influenced by many of the decisions made then. Thousands of dollars can be saved — or wasted — later on, in the corrosion control program, as a direct result of things done or not done long before the line is built.

At the present state of the art, there is only one reasonable corrosion control program for a pipeline — coating plus cathodic protection. Theoretically, either of them alone could do the job, but the coating would have to be perfect and remain perfect, (considered practically, this is not possible) and cathodic protection, working alone on bare pipe, would be too expensive.

One of the early decisions to be made, then, is the selection of the coating system, and this decision will affect the amount of cathodic protection that will be required later. The better the coating initially, the less cathodic protection will be required. And the slower the deterioration of the coating, the more slowly will the cathodic protection have to be increased in order to maintain protection.

The Economic Problem

The problem here is an economic one. The better the coating, the lower the cost of cathodic protection. But better coatings cost more, and eventually a point is reached where another dollar spent on coating will save less than a dollar on cathodic protection costs. This is the place to stop.

In general, one of the "standard" coating systems will be found to be the economic solution: Glass-reinforced enamel with outerwrap, or polyethylene tape with outerwrap. The choice between enamel or tape, or the choice between enamel bases, is often made in the light of anticipated weather conditions during construction, or on the basis of contractor's preference as evidenced by bid prices.

But the problem is not always a simple economic one. If the line were located remotely, with no crossing or parallel lines, and no congested areas with underground utilities, the above considerations might apply strictly.

Under these complex circumstances, interference problems can be so difficult and time-consuming that every ampere of current by which the cathodic protection needs are lessened is a major blessing. For this reason, complicated and expensive multi-coat, multi-reinforced coating systems are often prescribed in order to reduce the current requirements to the very minimum.

Don't Overlook These Items

There are other items besides coatings that need attention in the planning stages. Insulated joints should be inserted in the line at certain points. Two major functions are served by these joints: (1) They separate the line itself from other structures, and (2) they break the line up into segments, which may be more easily handled one at a time.

CONSTRUCTION CHECK LIST

A. MAKE CERTAIN "SPECS" ARE FOLLOWED ON COATINGS:
   1. Proper storage of materials
   2. Correct handling
   3. Application only when weather conditions are suitable
   4. Adequate testing
   5. Correct quantities
   6. General good workmanship

B. CHECK APPLICATION
   1. With holiday detectors
   2. With a Pearson detector survey

C. CHECK EVERY CASED CROSSING CAREFULLY

D. CHECK EVERY INSULATED JOINT

E. WHEN OTHER LINES ARE CROSSED, BE CERTAIN THEY ARE PROPERLY SEPARATED

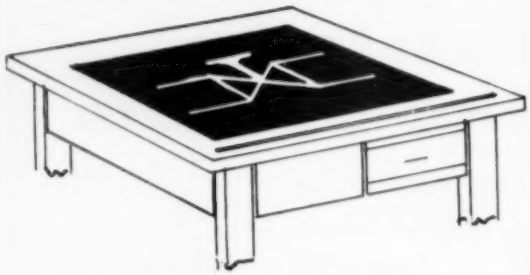
The other structures may be pipelines, such as gathering lines of different ownership, or they may be physically different things, such as tank farms, pumping stations, compressor stations, or other facilities. Separation in these cases is desirable, because current demands of such structures are likely to be very different from those of the line sections.

Separation of the line itself into independent sections is not so critical. In case of trouble later on it can be a real convenience to be able to test sections one at a time, but usually any protective system will involve tying all sections together.

One very important thing to watch is this: If there are insulated joints in the line itself, at river crossings or elsewhere, then either the joints themselves must be accessible, or there should be a well-protected pair of test leads brought up to an accessible location, one from each side of the joint. These are special leads and should be of heavier wire than the ordinary test leads, as these may be called upon to carry the cathodic protection current. For lines with good coatings, No. 4 wire will nearly always be adequate, particularly if the leads are short.

Joints that separate the system from other structures also should be accessible or be provided with test leads. Smaller wire is suitable in this application, No. 10 or even No. 12 being considered adequate. Where there are flanged joints above ground, as at meter runs, these should be chosen for insulation. Such joints should always be marked, and the outer rim of the two flanges should be encircled with a band of belting or tape to guard against accidental short-circuits.

(1) PLANNING FOR CORROSION CONTROL IN THE DESIGN



STAGES WILL SAVE MANY DOLLARS LATER.

In the design of cased crossings, it is recommended that casing supports should be used at about half the spacing recommended by the manufacturers. Their recommendations are based on the load-carrying ability of the supports, and can be depended upon to prevent short-circuits *only* if both pipe and casing are absolutely straight. As this is not always the case, it is easy to see why there are frequent short-circuits at cased crossings. Particular care should be taken to see that a good reliable closure or seal is specified for the ends; most of the troubles occur there.

A possibility often overlooked is the additional current drain imposed on a system by a structure such as a suspension crossing or bridge. Usually such a structure will represent many square feet of bare metal in contact with the soil (or with concrete footings and anchors, which is essentially equivalent), and usually the line is solidly connected, perhaps even welded, to the structure.

The simplest solution to this problem is to use an insulated joint at each end of the bridge, thereby separating the buried line from the bridge. This solution will work *only* if the arrangement is such that the line on the two sides of the river is protected by different units. It is not practical to carry a cable across the bridge to connect the two buried sections, for example, copper cable of sufficient size would be prohibitively expensive.

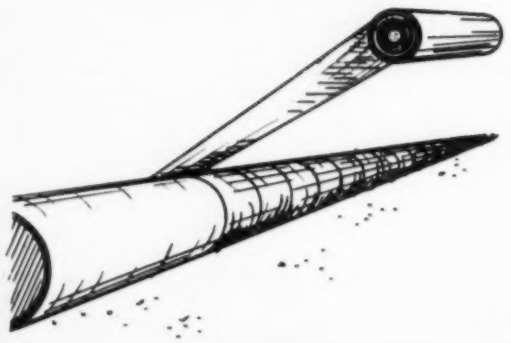
Test Lead Locations

Test lead locations will have to be specified during the planning stage also. Every point of significant change on the line should have one, i.e., every casing, every insulated joint, every foreign line crossing (except that where several lines are crossed in a short distance, one lead may suffice). It should be noted, however, that where the line itself is accessible, as at valves and junctions above ground or in boxes, leads are convenient but not necessary.

After these special locations are taken care of, enough additional leads should be specified to give a good electrical picture of the line. On well-coated lines, one every 10 or 15 miles is enough — but just barely — and if roads are more frequent, so should test leads be. A mistake often made is that of specifying "a test lead every five miles," or some other spacing, without naming the actual locations. A literal minded contractor will install them at exactly five-mile intervals, with no regard to their accessibility, and he cannot be blamed for doing so. To get the best results, the exact locations should be specified. Another way of achieving this result is to leave the locations open and let an inspector specify them during construction.

One other detail can be handled in the planning stage in such a way as to save a great deal of trouble later, and that is the specification of adequate separation from all crossing lines. The contractor also should be required to report the location of all lines crossed, especially those that were not known to exist until discovered during the work.

(2) USE THE BEST POSSIBLE COATING WITHIN ECONOMIC LIMITATIONS.



About the Author

Marshall E. Parker *is a consulting corrosion engineer with headquarters in Houston, Texas, whose work is chiefly concerned with the cathodic protection of pipelines. This work has taken him from the banks of the Rio Grande to the banks of the Yukon. Formerly corrosion engineer for Pan American Pipe Line, he has been a consultant since 1949. He is the author of numerous articles on the subject, and of two books. He is a graduate of Sam Houston College and of Rice Institute, and is a registered professional engineer in Texas.*

Construction Phase

During the actual construction of the system, one of the prime occupations of the owner is that of inspection. From the standpoint of corrosion, probably the most important phase of inspection is the coating. **There is far less difference between different kinds of coating than there is between a properly and an improperly applied coating.**

This means that inspection is more important than specification — a peculiar conclusion, but a true one.

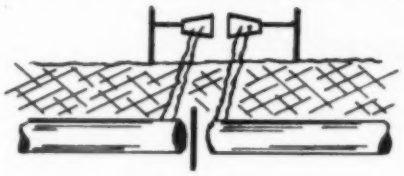
The task of the inspection group assigned to the coating —and it should be a group — is to see that the coating is applied according to specifications. They cannot reasonably ask for more, and they should not be expected to accept less. This, of course, means that the specifications themselves should be complete and thorough; should call for everything needed, but for **nothing that is not essential.**

Items to be covered include:

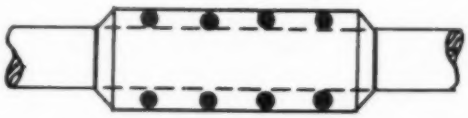
(1) Proper storage of materials;
(2) Correct handling;
(3) Application only when weather conditions are suitable;
(4) Adequate testing;
(5) Correct quantities;
(6) General good workmanship.

It is good practice to conduct a Pearson coating survey

(3) DON'T OVERLOOK

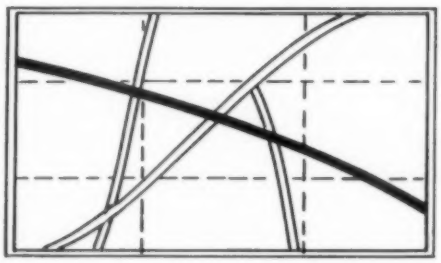


USING INSULATED JOINTS TO SECTIONALIZE THE LINE AND ISOLATE FROM FOREIGN STRUCTURES; BE SURE TO INCLUDE TEST LEADS AND NOTE EXACTLY WHERE THEY ARE LOCATED



ON CASED CROSSINGS, BE SURE TO USE PLENTY OF INSULATING SPACERS— MORE THAN MANUFACTURERS RECOMMEND

ISOLATE THE LINE FROM STRUCTURES SUCH AS SUSPENSION CROSSINGS OR BRIDGES



BE SURE TO LOCATE ACCURATELY ON MAPS ALL LINES CROSSED

as close as possible behind the backfilling operation, and to require the contractor to excavate and repair all large holidays found.

Ordinary holiday detectors are generally used to check the line after coating. They should always be on the job, and if not used to check every foot of the line, they should be used frequently. Primarily, their use should be employed to see that no basically incorrect practices are followed.

Where Special Inspection Is Needed

Adequate inspection calls for more than one inspector. In fact, there should always be at least one who has no assigned job. If every inspector has a specific assignment, then it may be necessary for the contractor to do something without inspection.

There are a number of items relevant to corrosion that require careful inspection, in addition to the coating and its application. Every cased crossing should be rigorously inspected. The best time to do this is when the line has been installed in the casing, but has not yet been welded in to the remainder of the line.

At this stage the resistance, as measured between casing and line, should be quite high — several thousand ohms in dry weather, at least a thousand in periods of high humidity; it can run as high as several million ohms. Once the line within the casing is welded in to the rest of the line, the value will fall to a much lower figure, and the determination of whether the installation is in fact insulated may require a more sophisticated technique.

Another reason for performing this inspection as soon as possible is that it is much easier to persuade a contractor to pull a crossing and do it over before it is tied in than it is later.

Similarly, insulated joints should be tested as soon as possible. Before they are tied in, or with only one side tied in, the ohmic resistance across one should be very high —thousands or millions of ohms, depending on the atmospheric humidity. After tie-in, the measured resistance is a function of the coating and the soil resistivity, and, as with a casing, it may require a more complex technique to determine the facts of insulation or non-insulation. Inspection at the time of installation, with remedial measures taken immediately, avoids a great deal of trouble with insulated joints.

By all means, a competent and reliable inspector should be present when any other line is crossed. Information about the separation between lines should be certain, not supposition, as should be the records needed to identify the test leads. The same thing is true of all test leads, whether they be singles, current measuring spans, casings, insulated joints, or crossing lines. An accurate and dependable description of exactly what was actually installed should be written up by a company representative at the time of installation.

It will be of great value to the company if personnel who are later to make up the corrosion department are on the job, preferably as inspectors, during the construction stage. They will gain a familiarity with the line and its surroundings that would be difficult to duplicate later. Their knowledge concerning such things as insulated joints and test leads is sure and positive knowledge.

At least one case is known where a corrosion engineer, engaged after the completion of a system, had an exhausting and frustrating time trying to conduct a current requirement survey without the information that the main line contained eight buried insulated joints without test leads. It did not seem to occur to anyone that he might not know about the joints, or that he needed to know.

In summary, the necessary protective system for a new pipeline can be most efficiently designed and operated if it is carefully considered during the planning stages, and if its needs are carefully provided for during the construction stage. ★ ★ ★

CORROSION REPORT

What Trans-Canada Is Doing to Protect Its System Against CORROSION

Covering 2290 miles, much of the route through rugged terrain, this pipeline is subjected to every known type of galvanic corrosion process

Lance F. Heverly, *Corrosion Supervisor, Trans-Canada Pipe Lines, Ltd.*

TO THE CORROSION ENGINEER and persons fundamentally interested in the prevention of corrosion, little need be said of the merits of cathodic protection. Most of us, having to do with underground plant structure, have many times read or heard of the high cost of corrosion — over $6 billion per year, of which over $600 million is for underground pipe maintenance and replacement alone.

In the economy vein, management is probably not so much interested in the number of leaks that can be prevented by cathodic protection as in the dollars that can be saved through their prevention as compared to the cost to realize this end. The price of leaks through possible explosions, shut-downs, loss of gas, or other product being transported, loss of revenue, cost of repairs, pipe replacement, early depreciation, bad public relations, and other intangibles can pay for a great deal of cathodic protection.

Fortunately, Trans-Canada Pipe Lines, Ltd., recognizes the need for preserving an expensive pipeline system against the ravages of corrosion. Since this line is such a long one (2290 miles) it is subjected to about every type of galvanic corrosion process in existence complete with stray current electrolysis and magnetic earth currents. Management is of the opinion that money spent to preserve a project costing from $145,000 per mile for 34-in. pipe in the plains country to $155,000 per mile for 30-in. pipe in rocky terrain is a good insurance investment.

It will be many years before any realistic figure can be arrived at for the savings through cathodic protection, but it is expected that we can equal that reported by other companies — as high as 30 percent per year on cost of cathodic protection. It has also been found in other companies that one good corrosion engineer spending full time on operation and maintenance of cathodic protection installations over approximately 250 miles of pipeline can do more to prevent corrosion leaks than one or two large maintenance crews and at one-quarter to one-tenth the annual cost.

Personnel and Training

Consistent with any other type of business, our first step in planning a corrosion control program was and is the procurement and development of personnel capable of being trained into becoming corrosion technicians. To this end, we have deviated somewhat from standard practices. Instead of trying to find experienced corrosion engineers with an engineering degree, a recognized impossibility, we have hired young men who have had senior

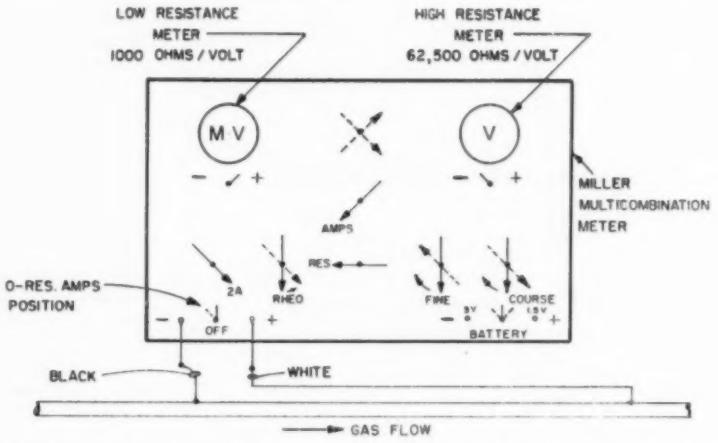


FIG. 1. Procedure for measuring external circuit resistance of all connecting wires preparatory to measuring millivolt flow on pipeline.

In this arrangement, the main selector switch is turned to RES, the LR meter switch (middle one) to AMPS, and the HR meter switch (top one) to some appropriate voltage scale starting on high voltage range.

Turn the polarity toggle switch underneath the HR voltmeter to the negative position.

Turn the internal battery toggle switch either to the right at 1.5 or to the left at 3 so as to obtain not over 1 amp test current.

The ampere scale switch should be turned to the 2-amp range or, if found more desirable, the 1-amp range.

The ammeter toggle switch below the LR meter should be turned to the left for short periods only — during time of current output adjustment, voltage scale selection, and simultaneous ammeter-voltmeter readings.

Using the COURSE rheostat, turn clockwise for current output — do not exceed 0.2 amp until rheostat is at its extreme clockwise end position. Turn carbon granule RHEO counterclockwise, if necessary, to limit this current.

Then, with COURSE rheostat in its extreme clockwise position, return carbon granule RHEO to its normal vertical position if it was necessary to turn it counterclockwise.

Turn FINE rheostat clockwise until no more than 1 amp is drawn from internal battery source.

Then take several simultaneous readings of current and voltage measurements for determining external circuit resistance.

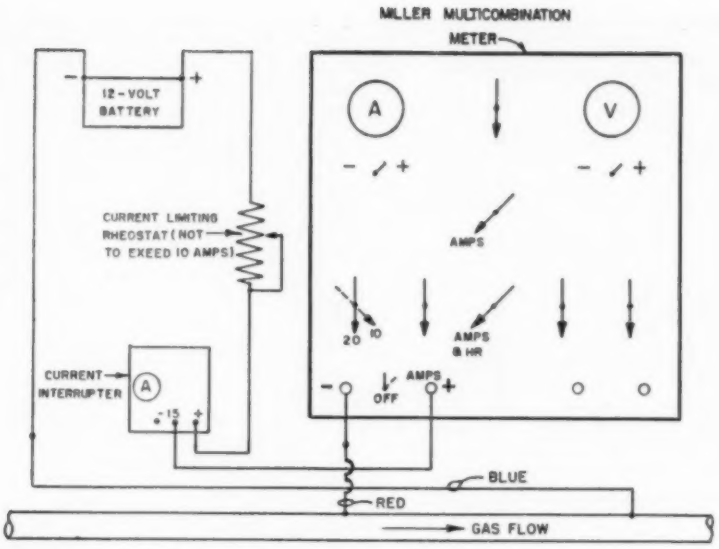


FIG. 2. Energizing circuit for use in calibrating the pipeline.
Make sure external current limiting rheostat is set for maximum resistance.
Connect car battery through ammeter and rheostat to Red and Blue test leads.
Initially leave ammeter range switch (selector switch at extreme left) straight up-and-down in 20-amp position.
Adjust rheostat to permit a maximum of 10 amp to flow.
If slightly less than 10 amp is allowed to flow, the 10-amp range switch may be used.
With this arrangement, make enough current measurements to be sure constant current is flowing.
Then remove lead wires from multicombination meters and clip together.
Observation of ammeter readings in Current Interrupter can be used as check to assure no change in test current.

high school matriculation, technology institute graduates, and men with one or two years of college. We plan to spend approximately two months a year for several years conducting a full time company school covering mathematics, electricity, and corrosion so these trainees eventually can assume the full responsibilities of a corrosion technician. This training is, first, to prepare the employee for preliminary field test work and installation of cathodic protection devices and, second, for operational maintenance. The balance of each year is spent doing productive work combined with continuous on-the-job training.

As it is recognized that the success of a corrosion control program and savings resulting therefrom vary directly with the knowledge, experience, and ability of the corrosion technician, every effort will be made to make his academic training period as short as possible. It is also recognized, however, that many years are required to develop the technical background and experience necessary to solve corrosion problems. Although the fundamentals of cathodic protection are relatively simple, the solution of technical and economical problems involved requires a high degree of training and engineering skill.

So, to enable our corrosion technicians to do productive work while learning, we have prepared detailed drawings explaining step-by-step procedure for making certain measurements. (See accompanying illustrations.)

Fig. 1 shows the settings to be made on the Miller Multicombination Meter for measuring the external circuit resistance of all connecting wires preparatory to measuring millivolt flow on pipeline. In our system of test lead connections, contact is made to black and white lead wires brought out in a terminal box. Spacing of these lead wires on the pipeline is 200 ft.

Once the resistance of lead wires has been measured, the same wires with same connecting test leads are used to observe millivolt flow on the pipeline both during calibration of pipeline and observation of static conditions. Knowing the internal resistance of the meter, the meter reading can be corrected to obtain the actual millivolt drop by the following formula:

$$\frac{\text{Meter resis.} + \text{ext. ckt. resis.}}{\text{Meter resis.}} \times \text{Meter rdg.} = \text{Actual mv drop}$$

If one were to use a millivoltmeter having a high meter resistance such as a vacuum tube type meter and low full-scale deflection, it would not be necessary to make any correction for external circuit resistance. Such a correction is a very simple process, however, with the multicombination meter. This circuit resistance also includes the resistance of the 30-in. pipe. By simple arithmetic, it can be seen that the pipe resistance represents such an insignificant part of the overall millivolt circuit resistance that it can be neglected.

Fig. 2 shows the energizing circuit used in calibrating the pipeline. In this set-up, connection is made to red and blue lead wires, which are Cadwelded to the pipeline just seven feet outside the black and white lead wire connections, respectively.

The current interrupter is used in this circuit to insure uniform timing for energized and de-energized periods. Once equilibrium conditions have been reached such that the current readings are constant, then the clips are removed from the multicombination terminals and clipped to each other. Normally, the car battery is used for the energizing source while the motor is running.

Possibly the use of the multicombination meter to measure current could be considered superfluous; however, with the rough treatment sometimes given the current interrupter, it provides a good check to place one meter in series with the other and takes very little time. After the clips are removed from the multicombination meter and clipped to each other, the ammeter on the current interrupter may be observed for energizing current values or for checking to see that there is no change in test current.

Fig. 3 shows the connection of the same lead wires whose resistance was previously measured as described in the step-by-step procedure of Fig. 1. The combination of circuits shown on Fig. 2 and Fig. 3 are then used for calibrating the pipeline.

Once the line has been calibrated and circuit resistance of millivolt connections has been determined, then Fig. 4 is used to show circuitry for making simultaneous measurements of pipe-to-soil potential and millivolt flow on the line. These measurements initially are made on the line before application of cathodic protection to determine original static conditions. They are also standard measurements that will be made after the application of cathodic protection.

All pipe-to-soil potential measurements are corrected to 25 C by adding 0.94 mv for each degree below 25 C and by subtracting 0.94 mv for each degree above 25 C. With the extreme fluctuation of temperatures along the route of our pipeline, this correction is quite necessary, especially in winter weather.

Because of the numerous tests to be made in corrosion work, we feel that detailed wiring connections of this nature will be most helpful to the new

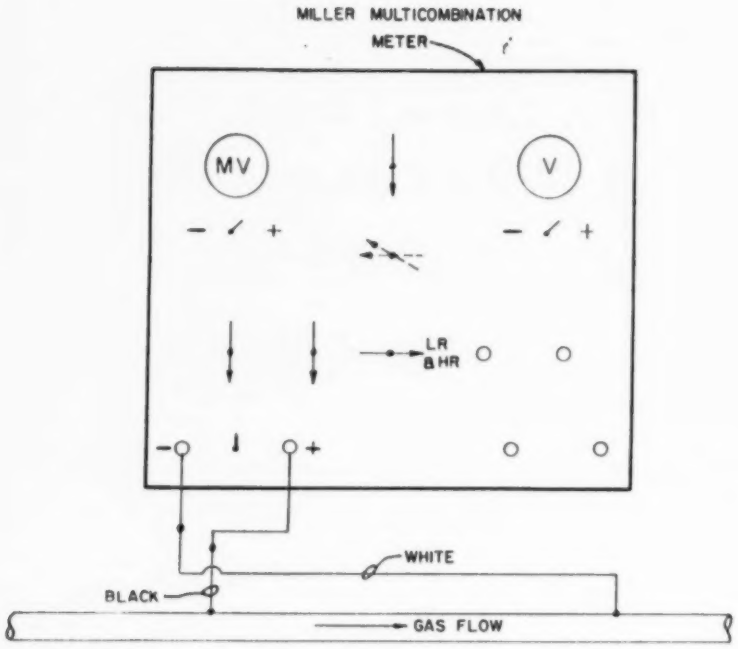


FIG. 3. Millivolt flow on pipeline used with pipeline calibration.
Use same lead wires whose resistance has previously been measured.
Turn main control switch (bottom center) to LR and HR.
Turn LR meter switch (shown by dotted lines) to proper full scale setting making use of large full-scale deflections initially.
Observe mv drop caused by energizing current. Record On and Off mv drop readings. Make at least 10 measurements. On data sheet, show corrected value of mv drop as well as observed meter values.
Note: Be sure to keep close observance of ammeter readings on current interrupter so that no error will result from possible change in energizing current.

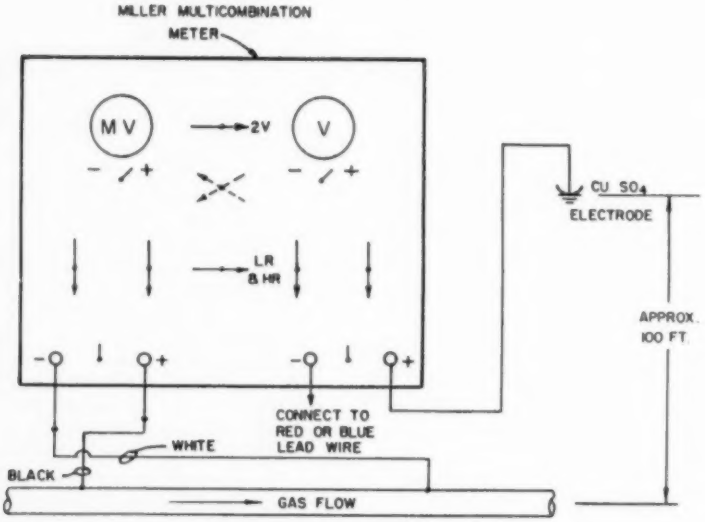


FIG. 4. Millivolt flow on pipeline and pipe-to-soil potential measurement.
Use same lead wires connected to LR meter terminals whose resistance has previously been measured.
Connect negative terminal of HR meter to either Red or Blue lead wire. Connect positive terminal of HR meter to copper sulfate electrode located approximately 100 ft from pipeline.
Turn main control switch (bottom center) to LR and HR.
Turn LR meter switch (shown by dotted lines) to proper full-scale setting making use of large full-scale deflection initially.
Turn HR meter switch (top center) to 2-v scale.
Observe mv drop and direction. If fluctuating, record maximum and minimum values, or reversals, and direction of flow. On data sheet, show corrected value of mv drop as well as observed meter values.
Observe pipe-to-soil potential. If fluctuating, record maximum and minimum values.

corrosion technician. While he is actively engaged in on-the-job learning, he is obtaining data necessary for initial design and subsequently for maintenance of cathodic protective systems.

Cathodic Protection Program

Coating applied to a buried pipeline represents the major protection the pipe receives against corrosion. The degree to which a coating performs its protective function depends upon several factors: (1) Materials used, (2) care with which it is applied, (3) care taken in lowering-in and backfilling, and (4) thoroughness of company inspection during these operations.

The cost of supplemental cathodic protection may vary from one-tenth of one percent to one percent of the overall pipeline construction costs. The degree of inspection taken by the various inspectors having to do with the application of coating and subsequent handling of coated pipe has a direct bearing on where in this cost range the price for cathodic protection will fall.

Regardless of how good a pipeline coating is above the ditch, it is subject to holidays and damage during lowering-in and backfilling processes, soil stress, and rock penetration. Moreover, most coatings are subject to deterioration in time through moisture absorption. Such coating failures tend to localize and concentrate corrosion action, which would accelerate local structure damage unless supplemental corrosion mitigation measures were taken.

In the construction of Trans-Canada's line, exceedingly rough terrain was crossed. Fig. 5 and 6 show pictures of granite type rock that had to be blasted to make way for the pipeline. In the construction of this line, 530 miles were through rock such as shown in these pictures. Fig. 6 also gives an idea of some of the steep mountains that had to be crossed combined with the rock problem. Fig. 7 shows a sample of swamp and muskeg areas that were encountered along the way. Muskeg, surprisingly enough, varied from approximately 3000 to 10,000 ohm-cm instead of being extremely low as one would normally expect.

In going through rock and muskeg, it was necessary to use a great deal of rock shield. It is to be noted that laminated type rock shield is excellent aid for pipe coating protection during construction; however, unless backfilling is with rock-free dirt or clay under and over the pipe in rocky areas, there can be no assurance that cathodic protection will ever do any good whatsoever.

Before the application of cathodic protection or before any attenuation

FIG. 5. In construction of the Trans-Canada line, 530 miles were through granite rock of the type shown here.

tests were made to determine cathodic protection requirements, a survey of static conditions was made on the line. This survey consisted of pipe-to-soil potential measurements and current flow along the line combined with calibration of the pipeline to enable us to convert millivolt flow to amperes.

As soon as these static tests were completed, attenuation tests were made to determine cathodic protection requirements.

Cathodic protection of our pipeline system is to be provided through the use of rectifiers and magnesium anodes. Our object is to protect as much of the line as possible with rectifiers placed at 20 to 40-mile intervals. Exact spacing depends upon the availability of power and results of attenuation tests.

Sufficient rectifier capacity is incorporated in the design to allow for coating deterioration and subsequent looping of the line. This is accomplished not by installing large capacity units in the beginning, but rather by the use of Add-A-Stack type rectifiers. In this manner, as the load increases more stacks may be added, thus operating at higher capacity and higher efficiency at all times.

Aerial Patrol Signalling

For airplane patrol signalling equipment, we have made use of standard equipment: Time switch, traffic beacon flasher, and yellow lens traffic beacon lights at the top of each rectifier pole. The timer and flasher run continuously, but electric power is supplied to the beacon lights only during daylight hours.

Regular 150-watt traffic bulbs are used in the beacon lamps as compared to the usual 67½-v traffic bulbs. These bulbs have long life, but in order to increase their life still more, they are operated at reduced voltage, presently at 108 v.

Beacon lights are arranged with standard 1½-in. pipe assembly at the top of the pole so that one is pointed along the pipeline in one direction and one in the opposite direction. The cover plate normally used over the lens at street intersections is installed wrong side up at the bottom so that the flashing beacon light will not be visible to vehicle traffic.

In those sections where rectifier protection cannot be economically obtained due to unavailability of power supply, magnesium anodes will be used. Based on soil resistivity measurements made to date, it is not planned to use anodes less than five feet long. As a matter of fact, in order to effect a low anode to earth resistance, it is expected that anodes 10 ft long will be necessary in many areas in order to obtain reasonable current outputs. Depending on soil resistivity, these anodes may be installed either singularly or in groups.

Rectifiers will be checked once a month by a corrosion technician and at least weekly by airplane patrol to insure continuous operation. Voltage and current flow readings will be checked at all test lead stations at least twice a year and more often in areas showing border line protective conditions.

So far in our cathodic protection program, we have covered the provinces of Saskatchewan and Manitoba. We plan to complete protection of our line from the Manitoba-Ontario border to Montreal, Quebec, a distance of 1475 miles, during 1959. In Saskatchewan and Manitoba, we were able to use all rectifier protection, 27 units in all. Because of the absence of power lines in Ontario, it is expected that we will have to make many magnesium anode installations.

About the Author

LANCE F. HEVERLY, *corrosion supervisor in the operating department of Trans-Canada Pipe Lines, Ltd., Toronto, Ontario, has had wide experience in corrosion work. He was an electrolysis crew leader for the Long Lines Plant Department of the American Telephone and Telegraph Company, corrosion engineer with Ebasco Services, Inc., and chief corrosion engineer with Great Lakes Pipe Line Company. He was graduated from Pennsylvania State College in 1938 in electrical engineering. Affiliated with many honorary engineering societies, Heverly is a member of the National Association of Corrosion Engineers, a registered professional engineer in the State of Pennsylvania and Province of Ontario, and chairman of NACE's Technical Practice Committee T-2D for Standardization of Procedures for Measuring Pipe Coating Leakage Conductance.*

Test Stations

During pipeline construction, test leads for determining pipe-to-soil potential were installed at approximately one-mile intervals. At all cased road, railroad, or aqueduct crossings, an extra test lead was installed on the casing to measure the electrical resistance between casing and carrier pipe.

At approximately five to eight-mile intervals, four lead wires were installed on the pipeline with spacing between connections as recommended by NACE Technical Practices Committee T-2D.

These sets of four-wire test leads can be used for many purposes. Basically, they are a means of calibrating the pipe for determining amperes per millivolt flow. They will be of even more significance in revealing such information as: The comparison of one coating material with another by comparing average coating conductances or resistances, comparison of one contractor's coating job with another's, comparison of inspection on one spread with that on another, and comparison of cathodic protection requirements under different environmental conditions for different coatings.

A test lead wire is installed at all foreign pipe and cable crossings to facilitate subsequent joint interference tests at the time cathodic protection is applied to Trans-Canada's line.

FIG. 6. Some of the rough terrain encountered is dramatically expressed in this photograph as the cleaning, doping, and wrapping machines descend a steep mountain with their crews skillfully controlling them.

FIG. 7. Sample of swamp and muskeg encountered along the way.

Insulating Flanges, Lightning Bypass

Insulating flanges are being installed at approximately 80-mile intervals to reduce effects of long line galvanic currents, stray direct currents, and magnetic earth currents. All compressor stations and sales meter stations are electrically isolated from the main line by insulating flanges.

To protect breakdown of insulation material at insulating flanges we are installing zinc anode plates as shown in Fig. 8 and Fig. 9. Due to mutual interference and equipotential between the two zinc plates, little or no current passes normally; however, in the event of a large potential gradient across the plates, such as may be experienced with lightning striking near the pipe or inducing current on the pipe primarily on one side of the insulating flange, these plates provide a low resistance path from one side of flange insulation to the other. Thus, the high induced current may pass by the insulating flange without rupturing flange insulating material.

Casings

Except for one section, all casings are being cleaned, primed, and coated externally. It has been found that whereas some of the coating obviously is scraped off during its installation, most is left intact. However, most coated casings that are found to be electrically shorted to the carrier pipe do not absorb an appreciable amount of cathodic protection current. For the most part, these shorted casings do not even pull down the potential of adjacent protected line. Just as in the case of bare casings, a shorted casing does, however, shield the carrier pipe and prevents that portion from receiving any cathodic protection current.

As an interesting comparison, it would take approximately as much current to protect cathodically one bare length of 34-in. casing 200 ft long as it would to protect cathodically approximately 54 miles of coated 30-in. pipe having a coating conductance of 78.5 micromhos per linear ft. This conductance is equivalent to an average coating resistance of 100,000 ohms for one square foot of area, a mediocre coating.

To prevent an electrical short between casing and carrier pipe, spacing insulators, end support cradles, and casing end seals are used.

Interference Problems

Some current discharged from rectifier and ground bed systems to provide

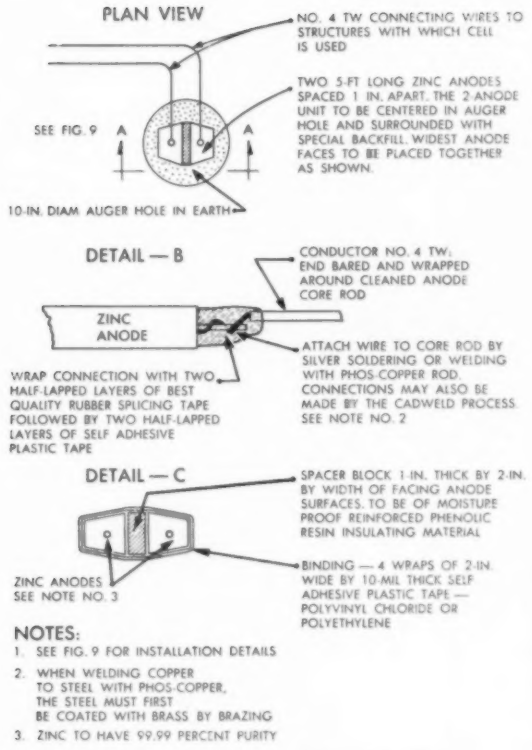
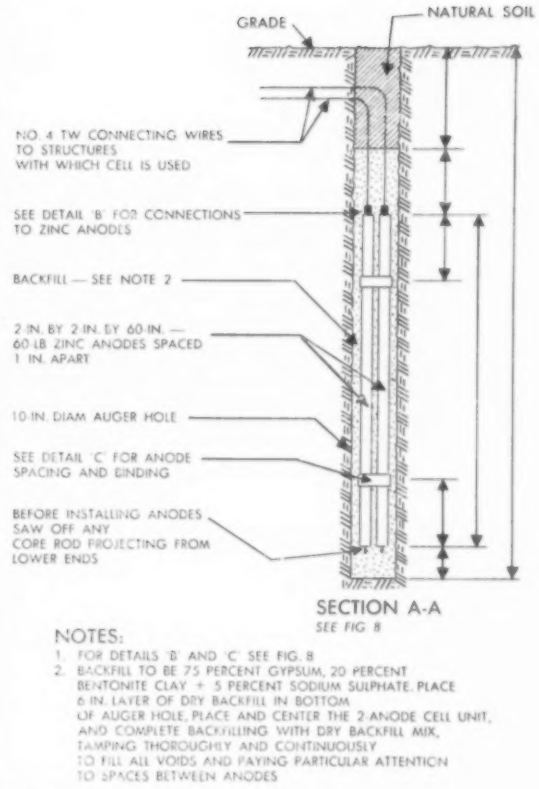

PLAN VIEW
NO. 4 TW CONNECTING WIRES TO STRUCTURES WITH WHICH CELL IS USED
TWO 5-FT LONG ZINC ANODES SPACED 1 IN. APART. THE 2-ANODE UNIT TO BE CENTERED IN AUGER HOLE AND SURROUNDED WITH SPECIAL BACKFILL. WIDEST ANODE FACES TO BE PLACED TOGETHER AS SHOWN.
SEE FIG. 9
A
A
10-IN. DIAM AUGER HOLE IN EARTH
DETAIL — B
CONDUCTOR NO. 4 TW; END BARED AND WRAPPED AROUND CLEANED ANODE CORE ROD
ZINC ANODE
ATTACH WIRE TO CORE ROD BY SILVER SOLDERING OR WELDING WITH PHOS-COPPER ROD. CONNECTIONS MAY ALSO BE MADE BY THE CADWELD PROCESS. SEE NOTE NO. 2
WRAP CONNECTION WITH TWO HALF-LAPPED LAYERS OF BEST QUALITY RUBBER SPLICING TAPE FOLLOWED BY TWO HALF-LAPPED LAYERS OF SELF ADHESIVE PLASTIC TAPE
DETAIL — C
SPACER BLOCK 1-IN. THICK BY 2-IN. BY WIDTH OF FACING ANODE SURFACES. TO BE OF MOISTURE PROOF REINFORCED PHENOLIC RESIN INSULATING MATERIAL
BINDING — 4 WRAPS OF 2-IN. WIDE BY 10-MIL THICK SELF ADHESIVE PLASTIC TAPE — POLYVINYL CHLORIDE OR POLYETHYLENE
ZINC ANODES SEE NOTE NO. 3
NOTES:
1. SEE FIG. 9 FOR INSTALLATION DETAILS
2. WHEN WELDING COPPER TO STEEL WITH PHOS-COPPER, THE STEEL MUST FIRST BE COATED WITH BRASS BY BRAZING
3. ZINC TO HAVE 99.99 PERCENT PURITY

FIG. 8. Zinc anode grounding. Cell construction detail.


GRADE
NATURAL SOIL
NO. 4 TW CONNECTING WIRES TO STRUCTURES WITH WHICH CELL IS USED
SEE DETAIL 'B' FOR CONNECTIONS TO ZINC ANODES
BACKFILL — SEE NOTE 2
2-IN. BY 2-IN. BY 60-IN. — 60-LB ZINC ANODES SPACED 1 IN. APART
10-IN. DIAM AUGER HOLE
SEE DETAIL 'C' FOR ANODE SPACING AND BINDING
BEFORE INSTALLING ANODES SAW OFF ANY CORE ROD PROJECTING FROM LOWER ENDS
SECTION A-A
SEE FIG. 8
NOTES:
1. FOR DETAILS 'B' AND 'C' SEE FIG. 8
2. BACKFILL TO BE 75 PERCENT GYPSUM, 20 PERCENT BENTONITE CLAY + 5 PERCENT SODIUM SULPHATE. PLACE 6 IN. LAYER OF DRY BACKFILL IN BOTTOM OF AUGER HOLE, PLACE AND CENTER THE 2-ANODE CELL UNIT, AND COMPLETE BACKFILLING WITH DRY BACKFILL MIX, TAMPING THOROUGHLY AND CONTINUOUSLY TO FILL ALL VOIDS AND PAYING PARTICULAR ATTENTION TO SPACES BETWEEN ANODES

F.G. 9. Zinc anode grounding. Cell installation detail.

cathodic protection to one structure may enter a nearby structure and traverse it for a distance while enroute to the protected one. When this current leaves the nearby structure and enters the soil, corrosion occurs that is similar to street railway stray current electrolysis.

This type of adverse interference can be prevented in several ways. First, in the design stage, the location of rectifier and ground bed usually can be chosen to place them sufficiently remote from a foreign structure to minimize the possibility of this type of adverse interference. Second, should interference occur, anodes could be installed in such a manner on the structure receiving interference to permit return of interfering current via the anodes. This interference current also can be returned to the intended structure through proper resistance bonding between structures at the location where the current would otherwise leave the foreign structure. With proper resistance bonding, just the right amount of protective current is drained from the foreign structure to offset the amount collected on it at other locations.

It is our practice to maintain at least 24-in. clearance when going underneath another pipeline or cable and request that others do likewise when undercrossing us. We also double coat and wrap our line for 100 ft to each side of the crossing. In this manner, the spacing and double coating reduces the danger of cathodic protection interference.

We propose to notify all owners of pipelines, cables, railways, and others having underground metallic structures that might lie in the field of our cathodic protection systems. Likewise, it is hoped that others having cathodic protection systems that could cause adverse interference on our pipelines will notify us so that we may have an opportunity to make joint interference tests with them.

These interference tests will be made in the standard accepted manner by checking the foreign structure potential to immediately adjacent earth with the interfering cathodic protection rectifier being alternately turned on and off. For no interference, there should be no change in foreign structure potential to adjacent earth when the interfering cathodic protection rectifier is turned on and off.

Cooperation Means Effective Control

Cathodic protection as a supplement to a good coating provides for an excellent corrosion mitigation program. It would not be economical to try to make either one perfect enough to prevent corrosion by itself. Once this approach is accepted, there must be cooperation all along the line for maintenance of effective corrosion control.

Besides management's backing for corrosion mitigation processes, the cooperation of all company design engineers and operating personnel is required to make the overall plan a working success. Any change or addition made to underground pipe or plant facilities should be brought to the attention of the corrosion engineer for study of possible effects on the corrosion control program. As a routine basis, copies of all correspondence, agreements, contracts, maps, drawings, etc., having to do with changes, repair work, or the like, should be forwarded to the corrosion engineer. The corrosion engineer should be notified of pipe or other underground structure excavations so he can arrange either to be present himself or have a field representative from his department present to observe pipe coating conditions of excavated pipe.

In all, the corrosion department head not only must maintain constant vigilance in his own specialized field of guarding against corrosion, but he must sell all other operating personnel on the importance of work procedures that safeguard against corrosion. * *

CORROSION REPORT

NEW LIFE FOR OLD PIPE

Frank H. Love, *Editor*

Sinclair takes up and reconditions pipe, some of which has been in ground for 37 years, and finds an astounding amount of it usable

How fast does buried pipe corrode?

That is a moot question, of course, because the rate of corrosion depends on several factors, such as: (1) Type of soil in which pipe is buried, (2) whether laid bare or coated, (3) how well it was coated, and (4) whether it was given cathodic protection.

A logical following question is, "How long can pipe be in the ground and still have remaining usefulness?" To be more concrete, can a pipeline be buried for almost four decades, for example, and enough of it be salvable to warrant the cost of takeup and reconditioning?

Sinclair Pipe Line Company answered these questions to its own satisfaction when it had 250 miles of pipe between Teague and Huffman, Texas, salvaged from parallel 8-in. and 12-in. crude oil lines that had been replaced by a single 20-in. line.

Some of this pipe had been in the ground for 37 years! And 97.67 percent of the pipe was classified as usable.

Sinclair classified this pipe as follows:

Class 2: High-pressure grade of secondhand pipe.

Class 3: Low-pressure grade of secondhand pipe.

Class 4: Junk pipe and scrap.

When the project was completed, these were the statistical results:

12-in. pipe

Mileage taken up — 138.56,
Abandoned in ground — 0.77 mile.
Class 2 — 115.85 miles recovered. (83.6 percent).

Steps in Reconditioning Pipe

Pipe is cradled out of the ditch . . .

. . . and cut into 40-ft lengths with hand torches . . .

. . . then loaded onto trucks for hauling to a central yard . . .

. . . at the yard it is unloaded onto receiving racks . . .

. . . crooked joints are straightened . . .

. . . pipe is thoroughly cleaned by a stationary type machine . . .

Class 3 — 14.92 miles recovered, (10.77 percent).
Class 4 — 6.40 miles recovered, (4.62 percent).

8-in. pipe

Mileage taken up — 111.63,
Abandoned in ground — 0.53 mile.
Class 2 — 101.48 miles recovered, (90.91 percent).
Class 3 — 7.55 miles recovered, (6.76 percent).
Class 4 — 2.60 miles recovered, (2.33 percent).

It is interesting to note that 22,289 couplings from the 8-in. screw pipe were sold. They will be used in water wells, shallow oil well surface pipe, and water floods.

The 8-in. was lapweld screw pipe and had been in service since 1921. When laid it was primed, coated with a single application of asphalt, and wrapped with asbestos felt.

The 12-in. was seamless, plain end pipe, and was laid secondhand in 1933. Prior to that it had been in the ground for about two years between McLoud, Oklahoma, and Cobb, Kansas. When re-laid it was left bare and joints were about half electrically welded and half oxyacetylene welded.

To perform the reconditioning work a central yard was established first at Normangee and later moved to Conroe by the contractor, Trojan Construction Company of Oklahoma City, Oklahoma.

First step in the procedure was to strip the pipe with ditchers and backhoes. Pipe was cradled out of the ditch with sidebooms and given a preliminary cleaning. The line was then rough cut into 40-ft lengths by means of oxyacetylene hand torches, loaded onto trucks, and hauled to the yard. As the pipe was cradled out, the ditch was backfilled immediately.

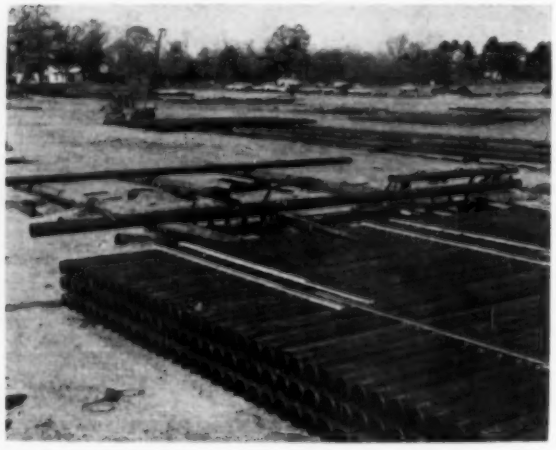
Upon arrival at the yard, pipe was tallied by Sinclair inspectors, who measured the length of each joint. Then it was unloaded onto receiving racks. After straightening any joints that required it, the pipe was thoroughly cleaned by a stationary type machine that removed all remaining coating and scale.

The pipe was then passed to the beveling racks, where it was graded and classified by Sinclair inspectors, after collars were removed (in the case of screw pipe) and pipe ends beveled. A specially designed portable grinder cleaned and put a 90-deg land on the bevels. The operation required less than 30 seconds for each bevel. From four to six grinders were in use at a time, leaving the pipe ends without feather edges but a good metal backing to make possible faster running of the stringer bead.

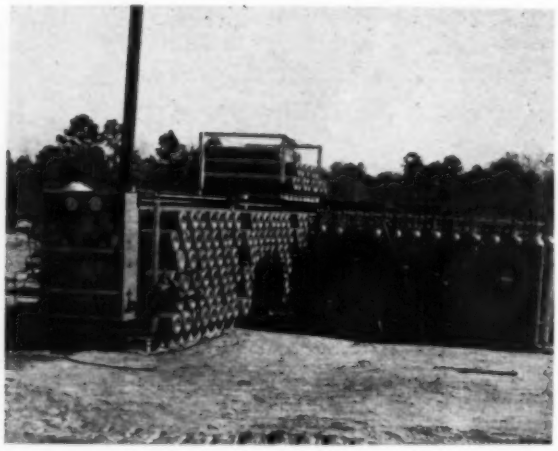
From the beveling rack the pipe was conveyed to the lineup rack. Internal lineup clamps were not used, as normally would be expected, as the dollies were arranged in a manner to bring the pipe joints into perfect abutment, unless a joint was bent, in which case the pipe would not feed onto the dollies at all. The stringer bead was run at the lineup rack, of course, but the pipe

. . . collars are removed (in the case of screw pipe) and pipe given a 30-deg bevel. In some instances as many as 16 beveling machines were in operation at a time . . .

. . . double-jointing and spot welding . . .



. . . Trojan-Lift — special equipment for stacking pipe . . .



. . . an unusual feature was method of supplying oxygen to the cutting and beveling equipment from a central point, known as the Cascade System.

was conveyed to another rack for completion of the double-jointing operation. Here three beads were run — hot pass, filler, and cap. It was at this location, too, that deep pits were burned out, spot welded, and ground down.

Before being placed in the permanent storage rack or loaded onto trucks for hauling out, the double pipe joints were checked through a final straightening machine.

One of the unusual features of the work was the method used to supply oxygen to the cutting and beveling equipment. The Cascade System, as it is termed, consists of some 40 or 50 oxygen bottles connected into one bank, with the oxygen piped to all parts of the yard through a 1-in. line. At each rack there was a gate valve to which the cutting and beveling equipment could be attached. A master instrument panel indicated the pressure of the entire bank and a master valve also was provided that could cut off the entire yard system. Tank trucks brought the oxygen in liquid form to refill the system. Bulk service of this kind effects a savings in cost of the oxygen and the unhandy handling of individual oxygen bottles is eliminated.

A special piece of equipment, used for the first time, was the Trojan-Lift, designed by the contractor and hence the name.

Its use was in stacking pipe in the yard after it was completely reconditioned. Basically, the equipment consists of two conveyor chains with hooks to hold the pipe. Arms of the conveyor can be adjusted for varying heights and pipe can be stacked as high as eight feet. When the pipe reaches the prescribed height it is automatically dumped on the stack. Driving power is a gasoline engine operating through a reduction gear.

Essential to an operation of this kind is an ample water supply. Pipe must be wet before going through the cleaning machine for best success in removing old coating and wrap. It is important, too, to keep dust settled in the yard, and, of course, there is the item of drinking water for the crew. This problem was solved at both yards— Normangee and Conroe — by the contractor drilling a deep water well.

Sinclair is keeping the 12-in. pipe for its own use and a part of the 8-in., selling some of the latter. The first 60 miles of 12-in. reconditioned at Normangee is being laid in its system from Wichita Falls to Jacksboro, Texas. This pipe was yard coated. Clem A. Mayes & Son, coating contractor of Lake Charles, Louisiana, set up facilities in the reconditioning yard for performance of the work. ★ ★ ★

CORROSION REPORT

Tests That Tell Quality of Pipeline Tapes

Here are some of the laboratory procedures now in use and their "front office" counterparts

Wayne A. Johnson, *President*
Corrosion Rectifying Company

THE PAST DECADE has seen an increase in the use of pipeline tapes, applied to prevent underwater and underground corrosion of buried steel pipe. These plastic tapes — polyvinyl chloride, polyvinylidene chloride, and polyethylene — are termed "pressure sensitive."

In most types the tape has a thickness of 6 to 10 mils with 2 to 6 mils of adhesive applied to one side. The tape is applied to the pipe at normal temperature with no heating required.

Often a primer is applied prior to applying the tape. Primers used vary from a rubber base resin to coal tar primers.

Some tape companies urge the use of outerwrap to protect the thin film, but others do not recommend an outerwrap feeling that their tape has sufficient strength so that with normal care it will reach the ditch in good condition and at a cost savings.

Many thousands of miles of lines coated with tapes have been in the ground for a number of years and performance records are piling up that show which tapes perform the best under numerous soil conditions. These records in most cases are quite favorable, and will eventually result in the better tapes being proved so and the others falling by the wayside. In the meantime the average user is confronted by salesmen whose sales approaches regarding the respective merits are sometimes contradictory. The purpose of this article is to explain some of the present laboratory tests run on pressure sensitive tapes and list their "front office" counterparts.

Strength

A good tape should be strong. It should have about the same tear strength in one direction as the other. It should resist penetration by stones or other sharp objects. It should show resistance to abrasion.

Fig. 1 shows one mechanical test being conducted on a tape film. The steel ball is allowed to drop on a strip of tape; then, a highly conductive

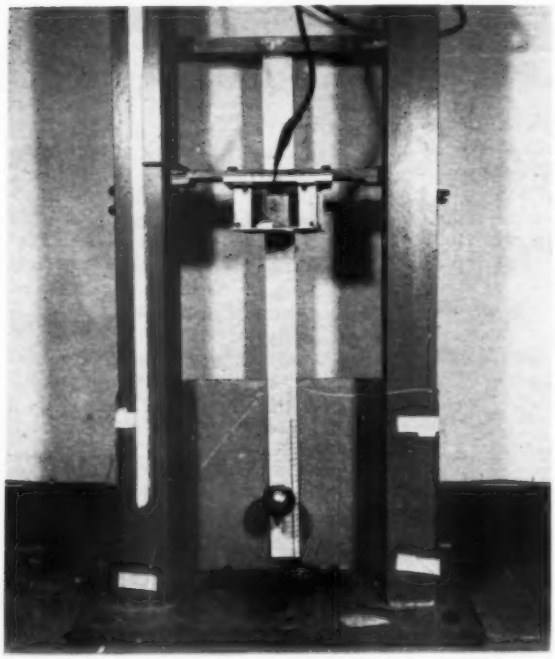


FIG. 1.

FIG. 2.

electrolyte is placed on the damaged area and the electrical resistance measured through the damaged area with an ohmmeter.

Fig. 2 shows a tear test machine, which stretches the tape until it breaks.

Fig. 3 shows a penetration test in progress. The force required to penetrate a unit area is measured.

Fig. 4 shows the result of an abrasion test. The taped pipe samples were anchored inside the container filled with aluminum oxide and water. Tumbling the container continuously for 200 hours produced the results shown.

The "front office" counterparts of the above tests are simple: First, try to tear the tape lengthwise and crosswise. It should have about the equivalent strength in both directions. Some tapes split easily in a lengthwise direction. Therefore, testing for tear strength in both directions is important.

Try to stick a sharp pointed pencil through the tape. If the pencil point "pops" through easily it shows that the tape may have little resistance to penetration by stones and other sharp objects found in the pipeline ditch.

Rubbing a file or coarse sandpaper for a couple of minutes over tape applied to a small piece of pipe will indicate its abrasion resistance.

FIG. 3.

Adhesion

It is the purpose of the pressure sensitive adhesive to hold the tape onto the pipe in the same position at which it was originally applied. The thickness of the adhesive has some importance, but more important still is the "grab" or "hold" characteristic of the particular adhesive. If an adhesive is too thick, and has a poor hold characteristic, the tape will slip and slide, and will be at the mercy of soil stresses, which eventually may expose the pipe at the overlap area. Firm adhesives remain in place.

Fig. 5 shows three tapes being tested for their adhesive quality. Tapes No. 3 and 4 already have slipped. The longer a tape remains stuck to the board the better the adhesive.

The "front office" counterpart of this test is simple: Stick two competitive tapes to the desk top overhang with a small weighted object attached to each and see which remains for the longest time, or even simpler, stick the end of a roll of tape to the desk top and test the adhesion by pulling on it.

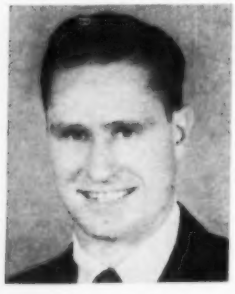
Some adhesives are so poorly bonded to the plastic tape that they actually peel from the tape when the tape is removed from a piece of pipe to which it has been applied. This is easily demonstrated by applying a piece of tape to a small piece of clean pipe.

Flexibility

A good tape has both conformability and elasticity. It should return to its original form after being stretched moderately, but it should have sufficient conformability to follow the many irregularities of pipe surfaces. Stretching by hand a unit length of tape will reveal its elasticity. To test it for conformability apply it over a rough surface pipe, welds, and joints. A tape that will not conform to the surface that it is to protect will do a poor protection job.

Electrical Resistance

To prevent soil corrosion a tape must have good electrical qualities, for it is the discharge of minute quantities of electrical current that cause soil corrosion. Tapes that initially show poor electrical quality, or whose characteristics change and become good electrical conductors, will not do a good job of protecting buried pipe.



About the author . . .

Wayne A. Johnson *is president of the Corrosion Rectifying Company of Houston, Texas, a firm specializing in designing and installing galvanic anode type cathodic protection systems for the oil, gas, and construction industries. He is a graduate of Texas A&I College and was a corrosion engineer for The Texas Pipe Line Company before organizing his own company a number of years ago.*

FIG. 4.

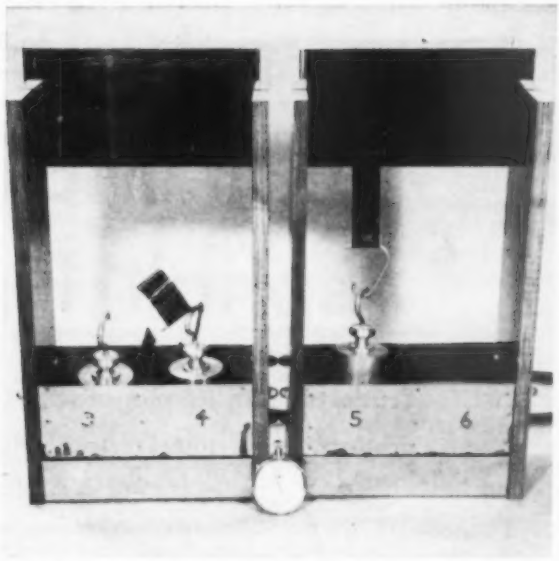


FIG. 5.

Tapes may be tested by a "holiday detector" but it is best to use voltages of less than 10,000 because of the thinness of tapes as compared to the hot applied types of coatings.

Fig. 6 indicates the relative electrical resistance of three competitively priced tapes. The electrical resistance of No. 1 has remained the same whereas tapes 2 and 3 have experienced a considerable change.

The "front office" cannot duplicate this test, but a similar conductance test can be applied easily by using a low voltage battery, a milliammeter, a sink full of salt water, and a short (6 in. or 12 in.) piece of pipe that has been taped. Applying the voltage between the pipe and the sink (or steel tank) may, if the electrical resistance of the tape reduces, result in an increasing amount of current flow with time. Low current flow, or no current flow, indicates a high resistance electrical property, which is desirable.

Stability

Any good material should either not change physically or chemically, or should improve with age. Most available tapes display resistance to solvents and oils, and have relatively low water absorbency rates. The adhesives of some of the tapes dry out in comparatively short time leaving the pipe with nothing but a loose wrapper into which moisture can easily creep.

Fig. 6 shows that the tapes tested have changed, probably due largely to moisture absorption though there also may have been other causes.

A "front office" test can be conducted regarding the stability of the adhesive of tapes by merely leaving a piece exposed to the atmosphere for a week or two. If it is going to dry out some change should be noted within this period. Burying coated samples for several months may be sufficient to predict the long range behavior of the poorer tapes. Several years of such a test may be required to indicate changes in the better quality tapes.

There are many other laboratory tests that may be conducted to determine the overall effectiveness of tapes as pipeline coatings. Space limitations do not allow a full discussion of these.

All coatings need to be applied under good conditions to achieve maximum effective results. Hence, the application procedure should be superior, and the surface to which the coating is applied should be clean. Holiday inspection will reveal voids. Careful lowering into the ditch, and backfilling operation, will assure that the pipeline and its coating get a fair start in life. Then it is up to the tape to prove its worth under the soil conditions to which it is subject. ★ ★ ★

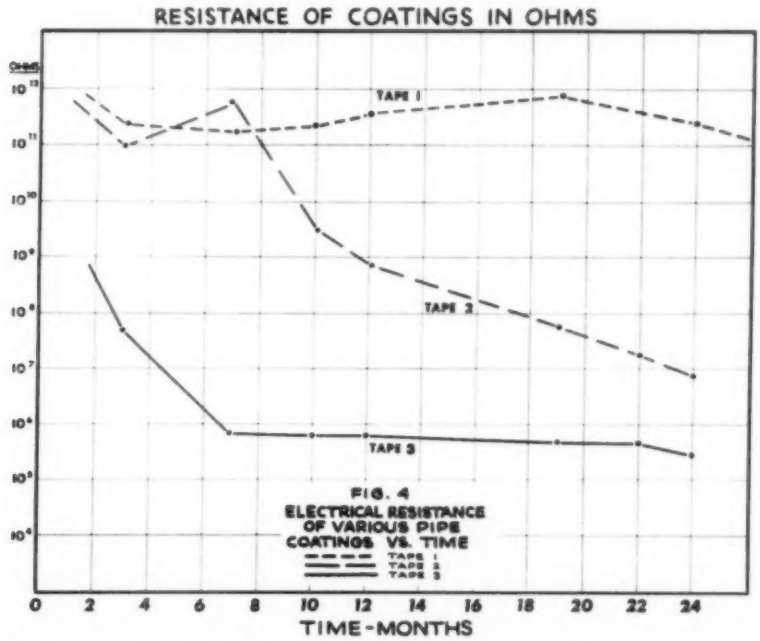


FIG. 6.

CORROSION REPORT

What Makes a Good Asphalt Pipe Enamel?

Crude used in its manufacture is highly important, and finished product must have certain characteristics — Here is how to tell

Lloyd Bramble, *President, Gulf States Asphalt Company, Houston, Texas*

ASK A CORROSION ENGINEER to name the most important single quality of a high-performance pipe enamel and he'll probably answer, "all of them are important."

Actually, that would be a thoughtful answer. There isn't any single quality. There couldn't be, not when the enamel has to withstand potential destruction imposed by a whole complex of mechanical, chemical, and electrical forces, beginning the moment the coating is applied and continuing for the life of the pipeline.

The first threat is human error, beginning at the dope kettle, resulting in an overheated enamel. Follow this up with thermal shock of application, particularly during extremes of cold weather. Then add wrenching and twisting as the pipe is lowered, followed up by backfill impact. And until the backfill has come to complete rest — about a year usually — additional stresses are developed in the ditch.

Once in the ground, the enamel is challenged by lineal expansion, pressurized expansion, by cycles of heating and cooling, by bacterial invasion, electrical bombardment, chemical attack. There are corrosive soils, earth heave, and the occasional presence of salt water. Finally, in mill-wrapped pipe, we have all these destructive conditions plus hazards involved in handling and transporting.

Obviously, an entire series of protective characteristics are required to guard against this wide range of destructive possibilities. Just how and where does a manufacturer begin in providing them?

Identifying Suitable Crudes

The first step is to identify a given crude as suitable for asphalt pipe enamel manufacture. But back of this technique of identification lies an enormous amount of research, which began in 1918 and continues up to the present. Comprehensive analyses of existing types of basic asphaltic compounds, and basic asphalt crudes, domestic and foreign, were made. Where asphalt residuals were not available, we obtained crudes and through distillation and reduction subsequently arrived at asphalt residuals. The problem of mixed crudes increased our problems, but in due time were overcome.

Conclusions can be drawn from given crudes from different refineries because, on the whole, large refining operations are remarkably accurate, varying only slightly from year to year. It is a literal fact that we have purchased, examined, and used residuals from large refineries that are absolutely the identical to those bought 10 years ago. This uniformity in basic material is notable and important.

Simultaneous with this research development, parallel projects involving asphalt were being undertaken and results evaluated, for use above ground, below ground, even under water. In these many different applications, various characteristics — of adhesion, cohesion, resiliency, stress resistance, etc. —were sometimes critically necessary and at other times unnecessary or even undesirable.

Testing Asphaltic Residuals

Based on this approach, by which characteristics of various asphaltic residuals were cataloged and then related to known protective or usage indices as promulgated in the lab and proved in the field, a mass of verified data was gradually developed.

One of the first things we want to know is whether a given residual was cracked during refining. A spot test gives us the answer, indicating whether any free carbon was left in the sample. If so, the material is disqualified for use as a pipe enamel, but not necessarily disqualified for other usages.

Surface appearance is then checked. Old-line asphalt technicians insist the job can be done without the microscope, but the younger men insist on using them. Startling as it may seem, it is possible to predict the origin of the crude from which the asphalt was extracted. Additionally, certain appearance means a given type of in-the-ditch failure.

Following its identification as suitable for use as a pipe enamel, a given residual is checked further, and its characteristics identified. These are then related to known performance indices. The result tells us the nature and amount of correction required.

Among the strengthening methods used is that of fillers. Potential interfacial tensions between metal and primer and primer and enamel, are eliminated by properly chosen fillers. Amorphous, finely-divided fillers, unaffected either by normal acids or alkalis, and of a size that 95 percent will pass through a 325 mesh, have been proved to be completely effective.

Testing Procedures

Following a succession of other steps, testing begins. Density, compressibility, thermal qualities, and permeability are evaluated. Coefficients of expansion are determined. Resistance to pressure, strain, vibration, shatter, and cold flow are measured.

Stability of a given material under

unusual temperature conditions is evaluated. It is perhaps unusual, but not entirely uncommon, for the dope pot to become overheated beyond specified margins. A thoroughly dependable pipe enamel should not be materially weakened by this treatment.

Chemical reactivity, dielectric strength, and dielectric losses are investigated. Stability under storage conditions is checked. Finally, the material is put to accelerated exposure tests, which reveal in a few days or weeks weaknesses that may take months or years to show up in the ditch.

Materials that withstand these laboratory and field tests we classify as

Lloyd Bramble

"high-performance pipe enamel." Two typical cases may be of interest.

Field Experiences

A revealing experience occurred in Refugio and Aransas counties, Texas. Twenty-six miles of 10-in. pipe were laid, about 10 miles near St. Charles Bay, in a tidal salt water flat.

The rise and fall of tides, aerates the salt water endlessly, presenting a corrosion problem of the first magnitude. The asphalt pipe enamel is under endless contraction and expansion, wetting and drying, heating and cooling. Lineal expansion of the line is multiplied many times beyond customary limits.

This has been going on for eight years, but there has been no increase in current demand to protect the pipe cathodically.

Another example: After more than one year's service, the electrical resistance factor on approximately 500 miles of 30-in. and 36-in. pipe averages 735,000 ohms per sq ft.

Specific Characteristics

Perhaps the question has occurred to you, whether it would be possible to specify high performance in pipe enamel in terms of specific characteristics. The answer is an emphatic yes.

Such specifications have not been made public before to our knowledge. The reason is easily understood. First, there are not many asphalt technicians. Then, the opportunity to be closely and continuingly associated in a broad research effort centered (in this case) around pipe enamel usages, is offered only to a small fraction of the practicing asphalt technicians. Finally, those with the experience and knowledge, and employed in that research effort, naturally would feel a reluctance to divulge facts not properly their own property.

However, with little effort and expenditure, you can determine for yourself the suitability of a basic material for pipe enamel manufacture. Here is a set of specifications that summarize several lifetimes of effort spent in this precise area. These specifications will guarantee you good to excellent performance for pipe enamels.

1. First: Determine that the basic asphalt in the finished enamel has a negative oleinsis spot test. This indicates a homogeneous product without excessive free carbon content.

2. Then, make sure that all physical characteristics are met:

Melting point, B&R	235-250 F
Penetration at 32 F 100/5	2 plus
Penetration at 77 F 100/5	3 - 8
Penetration at 115 F 50/5	7 plus
Flash point—C.O.C.	565 F plus
Settlement ratio, maximum	1.02
Low temperature crack test, 80 F	None
High temperature sag test (160 F, 24 hr)	None
Peel test, 60-160 F, 24 hr	None
Filler: Amorphous type, without shape,	
Filler particle size: 95% through 325 mesh	
Filler: Unaffected by normal acids or alkalis	
Ash, mineral filler % by weight	20-30
Specific gravity at 60 F	1.2

3. Be positive that the filler content is blue black or green slate four. Particle size 95 percent through 325 mesh. Particle shape not crystalline but without shape. No reaction either from acids or alkalis.

4. Subject the finished enamel to a cigarette paper stain test, which is conducted under a 200 gram weight and carried at a temperature of 125 F for 24 hours. The maximum stain shall not extend through more than two cigarette papers.

5. Note carefully the surface appearance of a sample freshly melted and exposed at room temperature for 48 hours. The appearance must be bright. There should be no noticeable exuding oils, or the amount should be insufficient to stain the filter paper under the slight pressure of the fingers.

6. Obtain a certified statement from your supplier backed up by evidence that the product has been submitted to an 18 months' outside weather exposure subjected to sunlight in either a south or southeast position on a metal panel, minimum size of 6 in. by 12 in. There shall be no evidence of checking or cracking, alligatoring or cracking after this 18 months' exposure. The film thickness on the metal panel shall be as near 3/16 in. as possible. ★ ★ ★

Protection of Submerged Pipelines

"Sacrificial Anodes for Submerged Pipelines," Robert G. Ransom, Tennessee Gas Transmission Company, Houston, Texas. Abstract of paper presented at South Central Regional meeting of NACE.

System expansion into offshore areas for gas supply has presented heretofore unencountered problems in regard to maintenance of submerged pipelines.

Protective requirements for offshore sections of the line remote from practical sources of impressed protective current, and subject to irreparable coating damage during installation, dictated use of a large amount of sacrificial anode material. Inaccessibility of the line after laying meant that reliability and long life were paramount design considerations.

An anode design evolved consisting of a sleeve or bracelet to replace a portion of the weight coating on certain joints of pipe.

The bracelet of anode material consisted of anode sectors assembled into an annular ring about the pipe using a circumferential steel band at each end for support. Working pressures involved prevented direct welding of the assembly to the pipe itself.

Anode material requirements included resistance to passivity in seawater, good current efficiency, relatively low driving potential, and molding considerations for the anode sector shape employed.

Because of the low electrical resistivity of the environment, the current distribution aspect was considered secondary to a standardized spacing for the pipelaying job. Then an anode length was determined to provide the necessary anode material for the protective requirements.

Experience gained with the completion of the first installation of 26-in. pipe has materially aided in the design of assemblies for subsequent pipeline installations of various diameters.

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As a basic producer, Pittsburgh maintains rigid quality control standards at every step of enamel production, from coal to finished coating.
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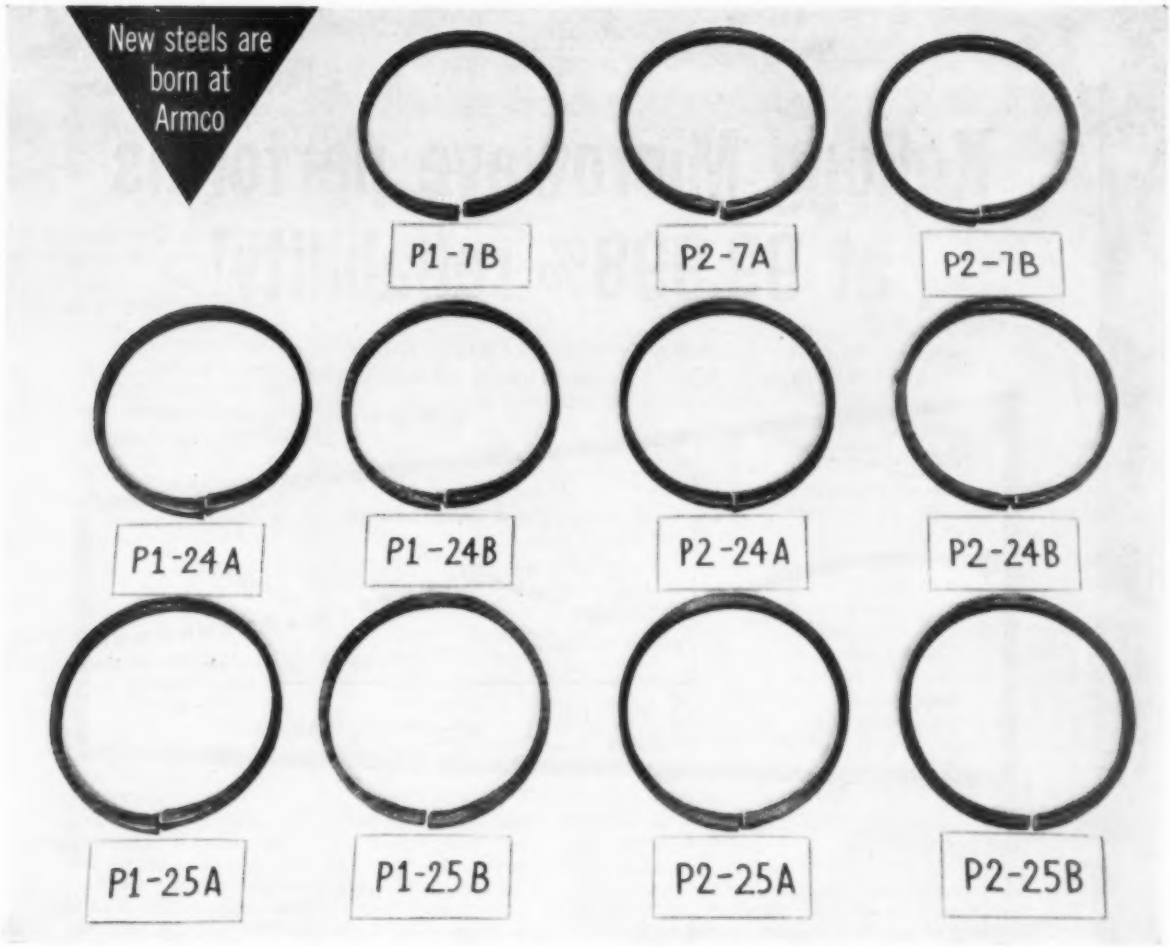

Photo shows a few of the random samples "sliced" from Armco Pipe, numbered, and tested for residual stresses.

How these test "slices" of Armco Line Pipe help insure safer lines for oil and gas

In line pipe, low residual stresses mean more strength in the pipe to meet unforeseen or accidental overloads. To measure these stresses, Armco cut ½-inch long rings from random samples of pipe, then severed them in the circumference. The amount of opening or spring-back of the free edges was used to determine the magnitude of the locked-up stresses, which ranged from 100 to 1000 psi.

The ring test showed that the maximum residual stress in Armco Line Pipe is about 90 PER CENT LESS than similarly measured stresses in many commonly used standard pipes. Get the complete story on the advantages and properties of Armco Line Pipe. Write for the free catalog, "Armco Welded Steel Pipe for the Oil and Gas Industries." Armco Drainage & Metal Products, Inc., 5519 Curtis Street, Middletown, Ohio, or 201 KOME Building, Tulsa, Oklahoma.

ARMCO DRAINAGE & METAL PRODUCTS

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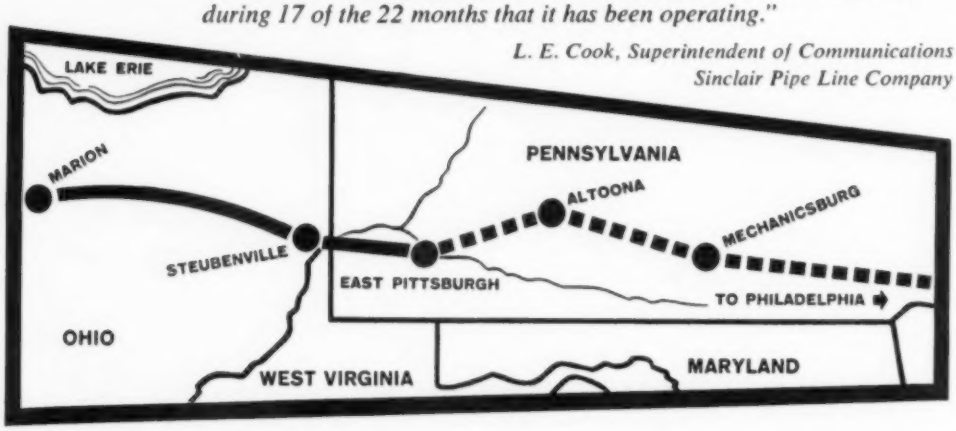
OTHER SUBSIDIARIES AND DIVISIONS: Armco Division • Sheffield Division • The National Supply Company
The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Kellogg Microwave performs at 99.998% reliability!

"...this system has performed exceptionally well...100% continuity during 17 of the 22 months that it has been operating."

L. E. Cook, Superintendent of Communications
Sinclair Pipe Line Company



Only five outages in the 22 months of service this Kellogg PTM Microwave System has been in operation for Sinclair Pipe Line Company, and only two of these totalling 2 hours and 51 minutes caused by the microwave equipment. That's 99.998% reliability, far superior to physical circuits!

Sinclair's dual path system was inaugurated on October 13, 1956. The present system stretches 200 miles from Marion, Ohio, to East Pittsburgh, Pennsylvania. It features 8 channels, 2 terminal stations, and 7 repeaters. All intermediate stations have drop equipment. At East Pittsburgh, circuits are joined by similar Kellogg 10C PTM systems extending eastward to Mechanicsburg then to Philadelphia.

Sinclair's dual path operation between East Pittsburgh and Marion, Ohio has many advantages over conventional systems, principally the elimination of all switch-over equipments or circuits. A failure of one of the units will not interrupt traffic, hence there is no traffic time loss as a result of switching to standby. There is increased reliability since both operating units are continuously monitored for condition of operation. Space or frequency diversity equipments may be operated with a minimum of additional components. In addition to this high degree of reliability and continuous performance, Sinclair reports that "the signal-to-noise measurements have exceeded the original calculations and the system has provided excellent performance since the inaugural date of operation."

The Kellogg Model 10C-2 PTM Microwave System now features up to 45 channel multiplexing equipments. Channels are readily arranged to suit the needs of specific installation whether for telemetering, remote control, data and voice transmission. Our engineering staff is always at your service ready to discuss your communication problems.

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Why Kellogg PTM Is Setting New Performance Standards:

Microwave has made huge strides since first pioneered by International Telephone and Telegraph Corporation in 1931. Here are 10 reasons why Kellogg's Pulse-Time Modulation Microwave, perfected by ITT research, is inherently superior.

1 Easy maintenance, particularly of the RF equipment; visual test and check methods may be used.

2 Tubes may be changed at random *without* realigning the Intermediate Frequency Amplifier.

3 Where propagation is a problem due to multi-path cancellation, it is simple to install space diversity reception equipment.

4 Drop channels may be installed at random, without need to demodulate entire groups to audio.

5 Economical system design: drop and insert channels may extend only throughout those parts of the system where required, and not the entire length.

6 Maximum transmitter tube life; tube life averages approximately 15,000 hours for 2C39s.

7 All PTM channels are interchangeable, only one spare is required.

8 High signal-to-noise ratio: the inherent noise of each channel is "clipped" out. Each terminal and each repeater station transmits a fresh signal.

9 Less tower rigidity required for accurate signal transmission at 2000 mc.

10 Plug-in channel units feature printed circuitry replacing tubes with crystal diodes; demodulators semi-passive, one tube per channel; modulators passive, no tubes. Results in 4:1 reduction in the number of tubes and 5:1 reduction in power consumption.

Investigate these and other advantages of a Kellogg PTM Microwave system. Write for complete details.

Pipeline Projects

Northern Natural Seeks To Expand Facilities

Northern Natural Gas Company has filed two applications with the Federal Power Commission seeking permission to build a total of 217 miles of main line extension, 221 miles of main line loop, and 1906 miles of branch lines—facilities needed to add 326 new communities to its system.

The 326 communities proposed in the two applications include: 170 in Iowa, 119 in Minnesota, 17 in South Dakota, 12 in Nebraska, 7 in Wisconsin, and 1 in Illinois.

Gas reserves for these two applications would come from Northern's supplies in the southwestern United States. The projects would require the construction of new compressor stations at Waterloo, Iowa, and Farmington, Minnesota.

The first application includes an extension of Northern's system from the Twin Cities to Duluth, Minnesota, and Superior, Wisconsin. Service to 39 communities is proposed in this application and will require an increase in daily system capacity of 52,500,000 cu ft of natural gas over a 3-year period. Estimated cost of this project is $25,000,000. In the second application, Northern requests permission to build facilities to serve 287 communities at an estimated cost of $76,000,000. This will require an increase in daily system capacity of 164,500,000 cu ft of natural gas over a three-year period.

Hearing Resumes March 10 On Transwestern Proposal

The Federal Power Commission has set March 10 as the date to resume the hearing on Transwestern Pipeline Company's application to build from West Texas to the Arizona-California boundary approximately 1809 miles of varying diameter pipeline and eight compressor stations with a combined capacity of 40,940 hp. Transwestern's proposal, at an estimated cost of $189,798,000, provides for the construction of two large diameter — 20 and 24-in. — lateral lines ranging from 250 to 325 miles in length, extending from the vicinity of the Hugoton field in the Texas Panhandle and from the Puckett area of the Permian Basin to Roswell, New Mexico. From Roswell, a 670-mile, 30-in. line would be constructed terminating at a point near Topock, Arizona.

Michigan Wisconsin Gets Temporary Okay On Project

Temporary authority to construct 352.9 miles of 24-in. pipeline loops and 16,560 hp in additional compressor capacity, at an estimated cost of $31,157,000, has been granted to Michigan Wisconsin Pipe Line Company by the Federal Power Commission.

The proposed facilities, to be built in Kansas, Missouri, Iowa, Illinois, and Michigan, are in lieu of nine intermediate main line compressor stations authorized by the FPC on June 20, 1958, which were to have enabled the company to take 40,000,000 cu ft of natural gas daily from the Laverne field, Harper County, Oklahoma, and to transport it through its main line system. The temporary authorization does not permit the operation of the facilities. The modified construction, the company said, would enable its system to transport a total of 80,000,000 cu ft of gas daily from the Laverne field. Michigan Wisconsin said it now has under contract in the Laverne field an aggregate of 631,256,000,000 cu ft of recoverable reserves, which, it claims, permit the increased takes.

Shell of Indonesia Plans $50,000,000 Project

Shell Oil Company of Indonesia has announced a $50,000,000 pipeline and drilling project for southeast Borneo which will include the building of a 161-mile, 20-in. pipeline connecting its refinery at the port of Balikpapn with the company's latest unexploited concession at Inaldn Tandjung. When completed at the end of 1961, the line will deliver 40,000 bbl of crude oil daily from 62 completed and planned wells.

Leonard Astley-Bell, Shell's general representative in Indonesia, said the British-Dutch company is gambling that the Indonesian government will correct problems he said are threatening the oil industry's existence in the island chain. He said the company anticipated that the government would grant a requested price increase on its products sold in Indonesia and would allow new concessions for development of unexploited areas. He warned that Indonesia's traditional oil markets were threatened by oil from the Middle East unless the government permits the development of new fields.

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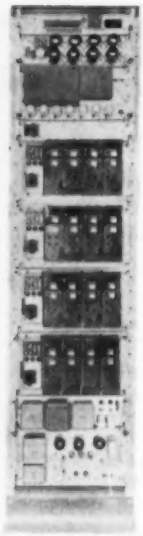

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CARRIER TELEGRAPH SYSTEM

AVAILABLE NOW

Transistorized • No relays required • Compatible with Western Electric 43A equipment • TWX Facility • No outboard vacuum tube amplifier needed • Why wait? Order and get delivery now!

BACK

Leading the industry in telegraph carrier development, Collins is *now delivering* TE-302 Systems, the first transistorized frequency shift telegraph carrier systems in operation at 60, 75 and 100 wpm.

Completely transistorized, the TE-302 System offers broadened performance and improved reliability. Major savings in floor space and costs of operation and maintenance are also effected.

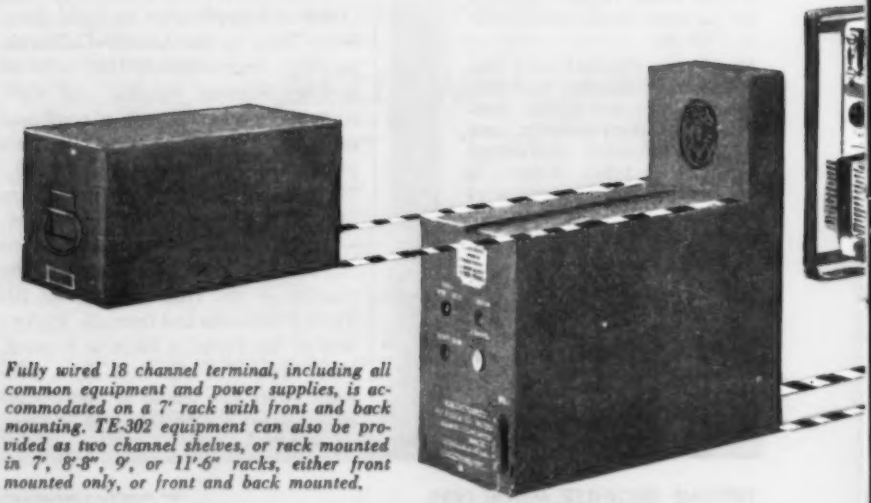
UP TO 26 CHANNELS: 18 duplex channels can be accommodated on a 4-wire voice circuit, or 9 on a 2-wire circuit. Another 8 channels may be added above the voice band between 3550 and 5050 cps.

TRANSISTORIZED CHANNEL UNITS: The TE-302 eliminates vacuum tubes and relays. This increases reliability and sharply reduces maintenance. Power consumption for the entire system is less than that formerly required for one channel.

PLUG-IN MODULES: The modular concept (photographically described on these pages) makes it possible to make initial installations of less than the maximum number of channels. New channel modules may be added as required.

COMPATIBILITY: TE-302 System and options are completely compatible with standard telegraph equipment, including Western Electric Type 43A.

For complete information about the TE-302 System, write Collins Radio Company, Texas Division Sales, 1930 Hi-Line Drive, Dallas 7, Texas.



Transmit and receive units for each channel are constructed in individual plug-in modules. Bandpass filter and tuned elements are contained in submodules which may be easily replaced for frequency changing. Collins etched wiring boards improve reliability.

Each mounting panel, which contains modules for two channels, fits standard 19" relay racks.

Fully wired 18 channel terminal, including all common equipment and power supplies, is accommodated on a 7' rack with front and back mounting. TE-302 equipment can also be provided as two channel shelves, or rack mounted in 7', 8'-8", 9', or 11'-6" racks, either front mounted only, or front and back mounted.

SPECIFICATIONS

FREQUENCY ALLOCATION:
26 channels, center frequencies from 425 to 5050 cps.

TRANSMISSION RATE:
60, 75 or 100 wpm.

MAXIMUM TRANSMIT LEVEL:
+6 dbm per channel.

MINIMUM RECEIVE LEVEL:
−45 dbm per channel.

BIAS DISTORTION:
5% maximum over any 10 db range between +6 dbm to −45 dbm input signal.

FREQUENCY STABILITY:
±2 cps over environmental range for channels to 3315 cps. For higher frequencies, 5% maximum change.

LINE IMPEDANCE:
600 ohms balanced.

ENVIRONMENTAL CONDITIONS:
0°C to +60°C ambient; humidity to 90%.

TELEGRAPH OPTIONS:
Full duplex neutral, half duplex neutral and back-to-back operation.

POWER SOURCE:
Commercial ac power or office battery 21-30 v dc, 130 v bias battery, and loop telegraph supply +130 v or −130 v.

POWER CONSUMPTION (per channel):
27 v at 60 ma, 130 v at 23 ma, plus loop current.

WEIGHT:
Approximately 500 lbs.

COLLINS

COLLINS RADIO COMPANY
DALLAS • CEDAR RAPIDS • BURBANK

FRONT

Alberta Gas Trunk Line Steps Up Growth Program

Alberta Gas Trunk Line Company, stepping up its expansion program in Alberta, has made application for construction permits for 122 miles of 30-in. extension of its main line northwest to Torrington, Alberta, with lateral lines to the Nevis and Carstairs areas. The revised 1959 program, to cost approximately $23,000,000, will enable the company to transport 446,000,000 cu ft daily during 1959-1960. In addition, the company intends to make application for 1959 construction of lateral lines to collect gas from South Provost area, the Medicine Hat area, the Makepeace area, Hussar and Wayne.

With proposed 1960 construction, the company could transport 585,000,000 cu ft daily in the year 1960-1961.

Compression facilities proposed to be constructed in 1962 will increase the carrying capacity of the system to 841,000,000 cu ft daily. The company has already made application to construct a large diameter gas line from Torrington to Dick Lake. The facilities built thus far and those proposed for 1959 and 1960 are designed primarily to handle the expanding eastern Canadian market.

Interprovincial To Add To Pumping Capacity

Interprovincial Pipe Line Company will have a very modest capital expenditure program for 1959, according to announcement by R. E. Trammell, general manager. Total expenditure of the company and its American subsidiary, Lakehead Pipe Line Company, will be $2,000,000, all of which will be provided out of retained earnings.

The program involves a new automatic electric-powered pumping station at Iron River, Michigan, rated at 6150 hp, the 21st station to be built on the 1930-mile line; and an extension to the main, electric-powered pumping station at Edmonton to increase its capacity by 4450 hp.

The new facilities will increase total throughput capacity of the system to 290,000 bbl per day out of Edmonton; 365,000 bbl per day out of Cromer, Manitoba; and 300,000 bbl per day out of Superior, Wisconsin.

Last year Interprovincial looped its main line for 82 miles to complete the dual line system from Edmonton to Superior, built an automatic booster station at Bay City, Michigan, and increased capacity of four existing stations in Saskatchewan and Manitoba.

Trans-Canada's Capital Expenditures $13,500,000

Capital expenditure of $13,500,000 will be made this year by Trans-Canada Pipe Lines, Ltd., on four new compressor stations and 15 sales meter stations, to bring the facilities up to a total of 10 compressor stations and 59 meter stations.

Three stations will be built on the Crown-owned northern Ontario section of line at Ignace, Geraldton, and Hearst. The fourth will be at Maple, a few miles north of Toronto, at the point where the 30-in. main line terminates and branches into the two smaller lines to Montreal and to Niagara Falls.

The construction program was announced immediately after the Alberta Government granted a supplementary export permit for the removal of 1.1 trillion cu ft of gas in addition to the 4.35 trillion cu ft already under permit to Trans-Canada. The additional quantity is all that Trans-Canada asked for in its latest application, although it is 400 billion cu ft less than the company had wanted originally for visible requirements. President James Kerr said that the total of 5.45 trillion cu ft now under permit, which will provide a maximum daily load of 785,000,000 cu ft, is adequate for all the demand the company can foresee at present.

BIG DITCH
LITTLE DITCH

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A pioneer in pipeline construction, Sheehan has handled jobs of all sizes, all types, in all kinds of terrain . . . Sheehan has "been there and back".

Sheehan's all-around experience pays off in more feet per day in the ditch . . . saves you money by cutting time and cost estimates. *Talk to Sheehan before starting your next pipe laying project.*

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Sheehan Spreads
cut costs
cut time
guarantee quality

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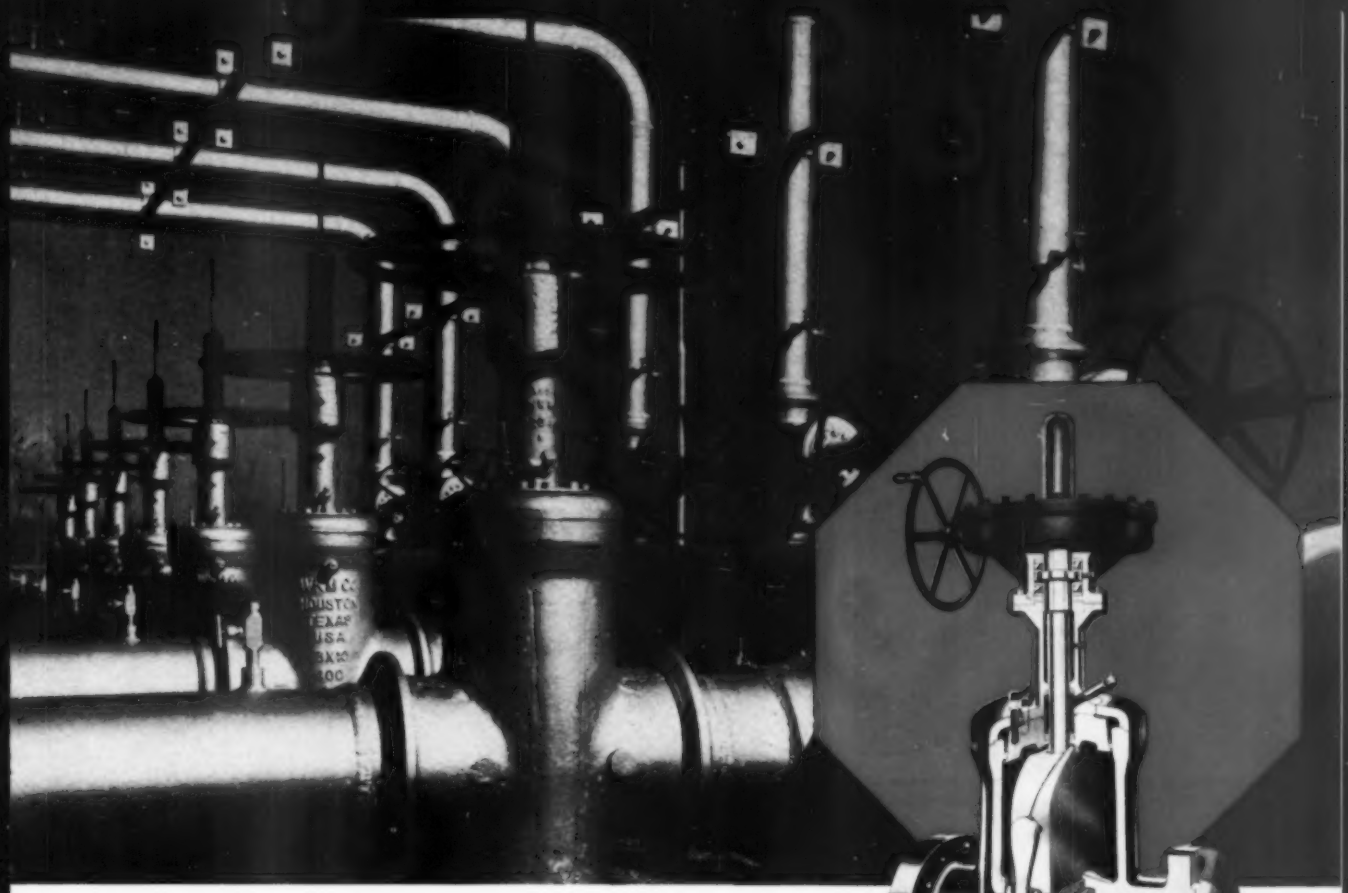

W-K-M's *Creative Engineering* gives pipeliners the answers to their valve problems

W-K-M's creative engineering process begins with your problems: design, production and field service are based on your needs. That's why W-K-M's ASA Gate Valves set the standards on pipelines throughout the world.

No other valve can give you tight seal upstream and downstream, *plus* the positive control of gate and segment afforded by W-K-M's exclusive gate centralizer.

No other valve gives you the same economical maintenance, the same long life combined with "on-the-line" overhaul.

For complete dependability and long-range economy, specify W-K-M ASA Gate Valves—they're the answer to all your pipeline valve problems.

TYPICAL!

This W-K-M ASA Gate Valve is typical of W-K-M's superior design, painstaking production, and thorough testing.

Features include: Through-conduit; pressure seal bonnet; parallel expanding gates; exclusive gate-centralizing mechanism; enclosed packing box; super-finished stem; seat lubrication.

Design assures: freedom from destructive turbulence . . . no surge operation . . . free passage for pigs or scrapers . . . on-the-line overhaul.

WRITE FOR CATALOG 300

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Pipeline Fundamentals

Understanding and mutual assistance between landowners and pipeline company personnel can prevent eroded farm land of the kind shown at left; instead, with proper conservation practices, there will be the kind shown at right where crops and goodwill both flourish.

Acquiring The Right-of-Way

Dudley L. Rankin, *Manager*
Wyco Pipe Line Company, Denver, Colorado

A right-of-way agent must have a combination of many qualities. He must be: (1) Humane and fair; (2) honest and just; (3) truthful and sincere; (4) personable — to make a good impression on first contact, since he is the first public relations man to represent the company, and (5) have knowledge of his job.

If he has these requisites he will be capable of performing the stringent duties required of him.

To be more specific, the right-of-way agent must be a competent appraiser to determine the fair market value of property. This usually consists of determining the amount of damages caused during construction.

He must be a technician sufficiently trained to explain the engineering details of pipeline construction and maintenance to the landowner when procuring the right-of-way.

He must be an authority on titles, easements, options, contracts, leases, and have a knowledge of legal decisions as they concern right-of-way acquisition.

He must develop a working knowledge of city, county, state, and federal real estate laws to make certain that right-of-way acquisitions are legally prepared.

He acts as a public relations contact man for the company for whom the right-of-way is being purchased, so a poor initial approach to a landowner or tenant cannot be tolerated, because oftentimes this would prevent good relationships between them and company personnel who operate and maintain the pipeline. Such a condition, should it occur, might last indefinitely.

With the aforementioned qualifications and duties one can readily see the valuable services performed from day to day by a good right-of-way agent.

PROCURING THE RIGHT-OF-WAY

All pipeline right-of-way should be purchased before the contractor begins construction, and sufficient time should be given agents to procure easements.

First step is to hire competent right-of-way agents to carry out the program. A most important factor, above and

Should the pipeline go over the hill or around it? In this instance it went around, but a decision is involved. To go around a hill might use less pipe, but it also would necessitate obtaining additional easements from landowners. Careful analysis is called for in the interest of total construction cost.

beyond obtaining the easement, is to do so honestly and, at the same time, establish a friendly atmosphere with landowners and tenants.

UNKEPT PROMISES

In order to obtain options, agents have been known to make promises that they knew were unreasonable and either would not, or could not, be kept. In some cases the right-of-way agent did his job insofar as obtaining the option was concerned, but made it doubly difficult for the person that settled damages, the contractor, the inspectors, and company employees who later operated and maintained the pipeline. Such practices have been minimized in recent years by requiring the right-of-way agent who obtains the easements to settle damage claims also.

SPECIAL REQUIREMENTS BY THE LANDOWNERS

If in order to obtain an easement the agent agrees to any special concessions, they should be written into and made a part of the easement. Normally, a pipeline is laid in a trench with a covering sufficient to permit normal plowing. Such situations necessitate 18 to 24-in. of cover; an average of 22-in. is a good figure.

The two things most often encountered in the way of special requirements is the depth and location of the line. Some farmers desire sufficient depth so they can use a deep rooter, which plows at times to 30-in. Consequently, depth of cover of as much as 36-in. may be required. This special concession adds to the cost of constructing a pipeline and should be avoided when possible.

Some landowners insist on specifying the exact location of the line on their property. Such landowners usually insist on certain distances from houses, barns, and farm buildings, or they may specify following property lines as closely as possible. Here again such requests may materially increase the construction cost.

The option form is usually easier to obtain and it permits construction without limitations. Ordinarily, it is unnecessary to define the location of the line and to specify the width of the right-of-way easement. After the line is laid, if a condition should arise whereby it becomes necessary to specify width of right-of-way, or other details, the company usually is in a better position to obtain adequate protection from the already obtained and recorded easement.

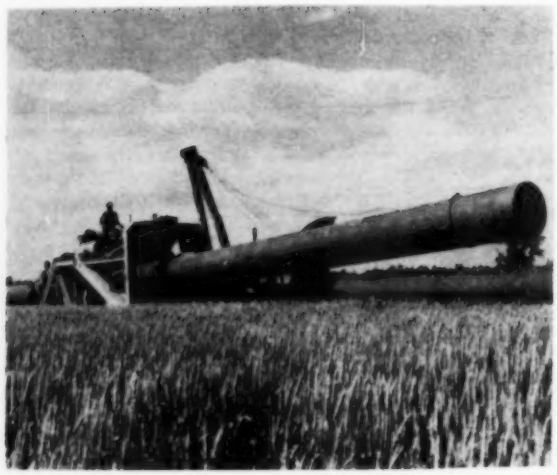
CROSSING IRRIGATION DITCHES AND CANALS

Rivers, streams, irrigation ditches, and canals may be crossed either by a submarine crossing or a suspended overhead crossing. Both are expensive. Normally, most streams and rivers are crossed with submarine crossings, because this is usually cheaper than overhead suspended piping. For the most part, the bottom of rivers and streams is the lowest point in the area where the pipeline crosses. This may not, and usually is not, the case with irrigation ditches and canals. These customarily carry water a long distance from the source to the lands where it is to be used, and are most often found along the side of a hill. Usually, it is hazardous, and frequently disastrous, to dig through an irrigation ditch or a canal to lay a submarine crossing, because it is almost impossible to pack disturbed soil, or riprap the area, sufficiently to prevent seepage through the disturbed bottom and bank when the water is again turned into the ditch or canal. Special tamping and paving with asphalt usually can accomplish this, but here again construction costs rise. Thus, an overhead crossing is desirable.

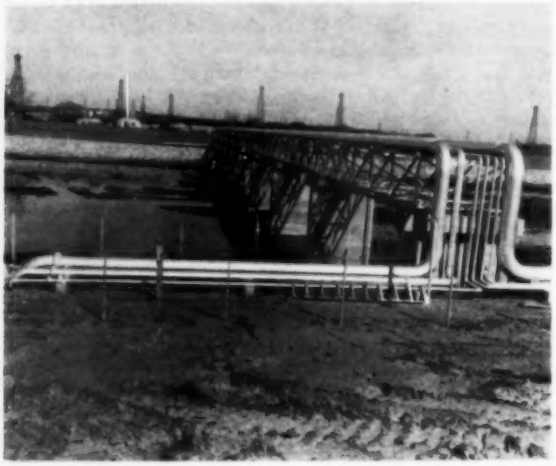
In many locations in the midwest stream and river erosion is constantly posing a threat to exposing submarine pipeline crossings—even to the extent of changing the course of the river. Should these conditions occur, it usually becomes necessary to do one of the following:

1. Lower the line and add the proper amount of river pipe to permit lowering.
2. Remove standard wall thickness pipe and install thick walled river pipe if the stream has completely changed its course.

Width of right-of-way must be sufficient not only for construction of the line, but also for its operation, maintenance, repair, possible relocation, and laying of second or third parallel lines.



The right-of-way agent must settle with property owners for any construction damages, one of which may be to crops. Here a pipeline goes through a wheat farm. If damage is done, the agent must be well versed on crop yields and prices in order to negotiate an equitable settlement.



Erosion caused by streams and rivers may necessitate lowering or relaying a pipeline. It might have been better to install an overhead bridge in the first place. Investigation of such possibilities is another duty of the right-of-way agent.

3. Construct overhead suspended crossings.

Oftentimes known stream conditions are the determining factor in installing suspended overhead crossings at the time the line is originally laid.

OVER OR AROUND HILLS

In surveying a pipeline along a straight line, it is normal to survey up and down a hill. Since a pipeline follows the contour of the ground, this may be the shortest distance. There have been instances where a route around a hill would require less pipe but also would necessitate obtaining easements from additional landowners. Total construction cost could be reduced by carefully analyzing such situations and cooperating with the engineers.

COMMUNICATIONS AND COOPERATIVE EFFORT

It has often been said that a chain is no stronger than its weakest link. This, truly, can be applied to the various groups engaged in a pipeline project. Not only does the actual communication of information play an important part, but the prompt cooperation and beneficial use of the information so furnished is essential to minimum construction cost.

Communications must be observed between surveyors, right-of-way agents, engineers, contractors, inspectors, and landowners and tenants. Many costly mistakes and misunderstandings can be avoided by keeping the above groups fully informed on matters of their specific concern as the job progresses. Cooperative effort improves proficiency and the efficiency of the overall project, and such errors as mentioned could always be avoided.

CROSSING UNDERGROUND MINERALS OR GRAVEL BEDS

A thorough study should be made of mining operations and mineral deposits in areas where such are prevalent. Usually this information can be obtained by contacting proper state officials.

Coal and other minerals oftentimes lie near the surface and can be mined by removing small depths of overburden soil. Also, sometimes overburden soil is too deep for pit mining but too shallow to hold up after the mineral is removed.

Should a pipeline unwittingly be laid over such mineral deposits, it usually becomes necessary to negotiate with the mining company to purchase minerals to prevent caving and possible rupture of the pipeline. It is easily seen that a serious situation would occur if a crude oil or products pipeline should rupture and seep its products into an active working mine. Explosion and fire undoubtedly would occur, resulting in serious damage to mine property, with possible loss of life.

It is far better to avoid such areas by laying the line in a location where such conditions do not exist. This cannot often be determined by surface survey, and the right-of-way agent should check in doubtful areas before purchasing right-of-way.

Right-of-way agents should question the advisability of purchasing right-of-way over gravel beds. There have been instances where gravel was not harvested for 25 to 50 years after the pipeline was laid, but nonetheless the pipeline company either had to change the line location or purchase the gravel that the owner was unable to claim. Both of these are expensive operations. Good gravel beds yield good income, and great quantities of gravel cannot be claimed if left to support a pipeline—such yardage must be purchased by the pipeline company unless a line relocation is cheaper.

HOUSING PROJECTS

Many times right-of-way is obtained and the land is later sold to a realty company for a housing development. Usually the pipeline crosses the area on a diagonal, which complicates the housing development. Such conditions usually occur long after the original right-of-way is purchased, and there is not much in the way of precautionary measures an agent can take when obtaining the original easements except to make local investigations as to the possibilities. If he finds that land may be developed in the future, he should contact the engineering division and suggest to them to alter plans and skirt the area along the property line to avoid heavy future maintenance and line changes.

In most cases, however, this is not known, and the first knowledge the pipeline company has of the proposed project is when a letter or telephone call is received requesting information on the location of the line and advising of the proposed housing project.

As most right-of-way easements do not specify actual location of the pipeline by legal description, negotiations must be entered into to determine what is to be done. First, a licensed surveyor must locate the pipeline accurately. Then the company establishes the actual width of right-of-

With proper construction practices pipeline right-of-way can be returned to a virtually undisturbed state.

Crop loss may extend over a period of years, but even after only one year some recovery is made.

way essential to maintain, operate, repair, change, relocate, or lay an additional line as provided in the easement. Right-of-way width varies with the diameter of the pipeline laid, but average pipelines can operate satisfactorily with a 50-ft right-of-way. In highly congested areas 20 ft minimum on each side of the centerline of the right-of-way has been necessary. Larger lines may require as much as 70 ft on either side.

Finally, it must be determined what construction can be permitted over the pipeline and the specifications and conditions that are acceptable to the pipeline company.

Negotiations between the pipeline company and the realty company then usually result in some satisfactory agreement—both sides granting concessions to reach a compromise. Results of such discussion and negotiations vary because actual location of pipeline crossings over property to be developed are different and the effect on the housing development probably has a different value.

In general: (1) No building construction can occur over the negotiated width of the pipeline right-of-way. Some courts have substantiated this. (2) Line relocation, if insisted on by the housing developers, will be done at the expense of the development company. (3) The pipeline will be cased under paved roadways at the expense of the development company. (4) Generally, the pipeline company will not pay any damages to improvements that are constructed on pipeline right-of-way after the line is laid, particularly when those desiring improvements are acquainted with the fact. The above conditions normally are included in the negotiated agreement.

DRAINED FARM LANDS

Laying pipelines in farm lands drained by a drain tile system is expensive, because water flowing through drain tile has to gravitate to the drainage location. The pipeline has to be laid through such land in a manner that will not interfere with the water flow through this subsurface drainage. Right-of-way agents, by investigating existing local

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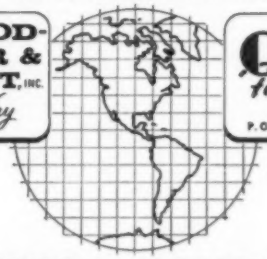

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conditions, may be able to avoid expensive construction by cooperating with the engineering division and determining an adjacent location on land not so drained.

RAILROAD CROSSINGS

Permits for pipeline crossings usually are obtained from the railroad and normally provide for an annual rental fee. The pipeline is cased over an agreed upon width on either side of the road bed, and the casing is set by boring under the railroad tracks. Some railroads used to require a block gate valve on either side of the railroad right-of-way, but this requirement has now been eliminated by most railroads.

HIGHWAY AND ROAD CROSSINGS

Form permits for pipeline crossings usually are obtained from state highway departments. Here, again, determining the method of construction is dependent upon conditions at the point where the pipeline crosses the highway. Because of the difficulty in compacting highway subgrade and interference with traffic, paved highways usually are bored for casing and main line pipe is pulled through the casing. The entire width of paved highway crossings is cased and a vent placed on one end of the casing on the highway right-of-way fenceline.

Graveled or dirt roads usually are dug and not cased. A problem does occur, however, that should be investigated by right-of-way agents when obtaining highway and county road crossing permits. Future paved road construction plans should be reviewed with the proper authorities. If some gravel or dirt roads are proposed for paving, the width of anticipated right-of-way should be determined and the information communicated to the engineering division of the pipeline company. Usually, in such cases it is desirable to case the pipeline as it is laid, for this is much cheaper than

Emergency repairs require use of large equipment, which sometimes results in damage claims.

Graveled and dirt roads usually are not cased, but right-of-way agent, when obtaining a permit, should investigate future plans for paving. If this is a possibility, it might be well to case these crossings when the line is first laid, as was done in this instance.

The Author

Dudley L. Rankin *has been manager of Wyco Pipe Line Company, Denver, Colorado, for the last seven years, and before that was with Standard Oil Company of Indiana for 28 years. He was graduated in 1923 from the Colorado School of Mines with a degree in petroleum engineering. He was recently given an 18-months leave of absence by his company to serve on the international staff of the North Atlantic Treaty Organization in Paris, France, where he is chief of the Petrol-Oil-Lubricant Section.*

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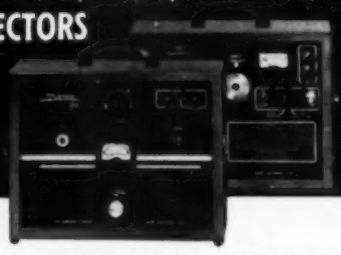

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casing the line later on. Such actions often result in an overall savings to the pipeline company.

LAND LEVELING

Farmers oftentimes have plans to carry out land leveling operations. The right-of-way agent, again, can effect potential savings by inquiring about this at the time he obtains an easement option. Often it may be much cheaper to dig the original ditch deeper so that land leveling can be done without the necessity of returning later on to lower the pipeline. This, of course, is dependent upon the depth of ditch required. Obviously, it would not be practical if the ditch had to be dug to an excessive depth for a long distance. In such cases it would be better to accept the calculated risk.

It should be realized that additional depth is an incremental expense when the line is being first constructed.

MILITARY ROADS

Construction of a military paved access road over a pipeline that had been laid after obtaining an original easement requires the attention of the right-of-way agent in negotiating a subrogated easement. In such cases the pipeline under-surface usage by the pipeline company is permitted by the federal government in return for the pipeline company's granting surface rights to the federal government. Usually, access for maintenance and repairs is provided the pipeline company by the federal government, and other provisions are the same as existed in the original pipeline easement. If lowering and casing are required, the federal government pays the expense.

INTERSTATE HIGHWAYS

Pipeline right-of-way agents are being confronted by problems arising from the construction of the interstate highway system. When a pipeline company has prior easement on private right-of-way, the states issue permits that are more liberal than the form pipeline crossing permits issued when a pipeline company wishes to lay across a highway right-of-way.

CONSTRUCTION DAMAGES

The right-of-way agent must settle with property owners and tenants for any construction or maintenance damages. There are many kinds of damages, real and imagined, and some are difficult to settle. It should be recorded, however, that in the many miles of pipelines throughout this country there are only a few owners who refuse reasonable damage settlements.

The right-of-way agent must pay for damages to pasture lands, loss of crops, timber cut to clear right-of-way, or burned on account of oil leak, damages caused by burning oil when leaks occur, livestock getting out of pasture during construction, erosion damage to land (oftentimes imaginary), loss occasioned by cattle not being able to get to feed or water during construction when provisions were not made by the contractor to permit this, damage to wells and underground water supply. Lack of feed and water could cause loss of milk production, butterfat production, or loss of weight in cattle being fattened for market. The right-of-way agent must know the value of many commodities and where to obtain current information on crop yields and prices.

Undoubtedly, there are other special problems encountered in pipeline right-of-way acquisition and operation that are not discussed in this presentation, many of which are important. It should be stressed however, that all employees beginning with the right-of-way agent's first contact, and continuing throughout the years, must be public relations-minded and create harmonious and cooperative atmosphere in dealing with landowners, tenants, county commissioners, state highway departments, and offices of the federal government. When pleasant relationships exist it is a simple matter for pipeline officials to meet with these people and present their problems and feel assured of fair and just treatment.

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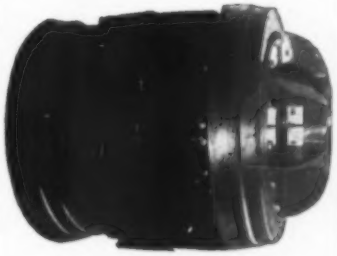

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"President Jefferson feared the justices some day would do what they now are accused of. A few months before he died President Jefferson wrote: 'There is no danger I apprehend so much as the consolidation of our government by the noiseless, and therefore unalarming, instrumentality of the Supreme Court'."

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WITH THE PIPELINE CONTRACTORS

● **B & M Construction Corporation, 2808 First National Bank Building, Oklahoma City, Oklahoma.** Has been awarded a contract to build 218 miles of 8-in. line for *National Iranian Oil Company* from Tehran to Resnt, Iran.

● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Constructing gathering system in Jack and Wise counties, Texas, for *Natural Gas Pipeline Company of America* to connect 84 new wells.

● **Collins Submarine Pipelines, Ltd., London, England. (Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.)** Has been awarded a contract by the *British Atomic Energy Authority* to install 12,000 ft of 6-in. pipeline at the shore at Winfritheath, England, (near Lulworth), to a depth of 80 ft, in the English Channel.

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● **Engineers Limited Pipeline Company, 225 Bush Street, San Francisco 4, California.** Has 102 miles of gathering lines in Aneth field, Utah, for *El Paso Natural Gas Company*.

● **C. N. Flagg & Company, Inc., 48 Elm Street, Meriden, Connecticut.** Has been awarded a contract by *North Carolina Natural Gas Corporation* to lay 102 miles of 3 to 6-in. pipeline.

● **R. H Fulton & Company, Box 1526, Lubbock, Texas.** Has been awarded a contract to construct 65 miles of 16-in. pipeline from Hobbs, New Mexico, to Wink, Texas, for *Permian Basin Pipe Line Company*.

● **H. L. Gentry Construction Company, 921 East Michigan, Jackson, Michigan.** Has been awarded a contract by *North Carolina Natural Gas Corporation* to construct in excess of 163 miles of pipe ranging in size from 6 in. to 12 in.

● **B. C. Hall Constructors, Inc., P. O. Box 644, Aztec, New Mexico.** Has contract to build an undetermined amount of various sizes of pipelines ranging from 4-in. through 20-in. for *El Paso Natural Gas Company* in the Four Corners area of New Mexico.

● **Hallmac Construction Company, 3701 Buffalo Drive, Houston, Texas.** Has been awarded a contract by *United Gas Pipe Line Company* to install 43 miles of 30-in. pipeline from Mandeville, Louisiana, to Kiln, Mississippi.

● **Harbert Construction Corporation, P. O. Box 1369, Birmingham, Alabama.** Has nearly 500 miles of 18-in. and 20-in. main gas lines and more than 600 miles of 4-in. through 16-in. lateral lines under contract with *Houston Texas Gas and Oil Corporation* from Bradenton, Florida, to Miami, Florida.

● **Hunsaker Trucking Contractor, Inc., P. O. Box 97, Carrollton, Texas.** Has contract to string 104 miles of 24-in. pipeline from Sulphur, Louisiana, to Smith Point, Texas, for *Coastal Transmission Company*.

● **International Marine Constructors, C. A., Caracas, Venezuela. (Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.)** Has been awarded a contract by the Iranian Oil Company to lay 25 miles of 30-in. at Ganaweh, on the Iranian shore, to Kharg Island, approximately 25 miles out in the Persian Gulf.

● **Macco Corporation, 14409 South Paramount Boulevard, Paramount, California.** Has prime contracts with various companies to construct pipelines in various sizes through 30-in. in California.

● **Majestic Contractors, Ltd., 408 Royal Trust Building, Edmonton, Alberta, Canada.** Has an undetermined amount of gas gathering system for *Producers Pipeline Company* in the Estevan, Saskatchewan, area.

● **McVean and Barlow, Inc., P. O. Box 151, Odessa, Texas.** Has a contract to build 116 miles of 20-in. pipeline for *El Paso Natural Gas Company* in West Texas and Eastern New Mexico.

● **Mid-States Construction Company, P. O. Box 417, Mt. Vernon, Illinois.** Has been awarded contract to build 5.5 miles of 4-in. from Gainesville junction to Gainesville, Florida; 46.5 miles of 16-in. from the Brooker main line junction to Jacksonville, Florida; and 7 miles of 3½-in. from the Stark junction to Stark, Florida, by Harbert Construction Corporation, prime contractor for *Houston Texas Gas and Oil Corporation*.

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Contractors

● **Midwestern-Walco Contractors, P. O. Box 11507, 1431 4th Street South, St. Petersburg 33, Florida.** Has been awarded a contract by *Houston Texas Gas & Oil Corporation* to lay approximately 700 miles of 24-in. main line between Baton Rouge, Louisiana, and Kissimmee, Florida, including a 24-in. crossing of the Choctawhatchee River at Caryville, Florida, and an 18-in. crossing of the Mobile River at Mt. Vernon, Alabama, and three compressor stations at Wiggins, Mississippi; Munson, Florida; and Quincy, Florida.

● **J. P. Neill & Company, Inc., 1200 Exchange Bank Building, Dallas 35, Texas.** Has been awarded 112 miles of 16-in. pipeline by *North Carolina Natural Gas Corporation*.

● **Oklahoma Contracting Company, P. O. Box 13227, Dallas 20, Texas.** Has contract for 130 miles of 24-in. between Lake Charles, Louisiana, and Baton Rouge, and 150 miles of 20-in. from Driscoll to Bay City, Texas, for *Coastal Transmission Corporation*.

● **Sheehan Pipe Line Construction Company, 514 National Bank of Tulsa Building, Tulsa, Oklahoma.** Has been awarded a contract to construct for *Buckeye Pipe Line Company* 11 miles of 6-in. pipeline from Verona, New York, to Rome, New York.

● **Vaughn & Taylor Construction Company, Inc., P. O. Box 3266, Odessa, Texas.** Has contract for waterflood system at Kamay, Texas, consisting of 55 miles of 2-in. to 12-in. line for *Shell Oil Company*.

● **Panama, Inc., 2201 Commerce Building, Houston 2, Texas.** Has been awarded a contract by *Humble Oil & Refining Company* to construct 238 miles of 30-in. natural gas pipeline from the King Ranch in Texas to the Clear Lake gas plant in Houston, Texas.

● **Sharman, Allen, Gay & Taylor, Inc., 3115 Buffalo Drive, Houston, Texas.** Has a contract to build 63 miles of 22-in. pipeline between Bay City and Galveston, Texas, for *Coastal Transmission Company*.

● **River Construction Corporation, P. O. Box 9127, Fort Worth 7, Texas.** Has contract to lay approximately 125 miles of 24 and 26-in. line in Mississippi for *Southern Natural Gas Company*. Also has been awarded a contract by *Coastal Transmission Corporation* to build 104 miles of 24-in. pipeline from a point near Sulphur, Louisiana, to Smith Point, Texas.

● **Somerville Construction Company, 6648 Fulton Road, Ada, Michigan.** Has a contract for 103 miles of 10-in. through 12-in. transmission lines from Pembroke to Goldsboro, North Carolina, and 60 miles of 3 and 4-in. lateral lines off these transmission lines from *North Carolina Natural Gas Corporation*.

● **Station Construction Company, 2807 Buffalo Speedway, Houston 19, Texas.** Has contract to build Norco terminal and Loutre Junction facilities in southern Louisiana for *Shell Pipe Line Corporation's* Delta crude oil pipeline.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has contract to build segments of a *Natural Gas Pipeline Company of America* line, consisting of 185 miles of 36-in. in Nebraska and Kansas, and 98 miles of 34-in. in Iowa.

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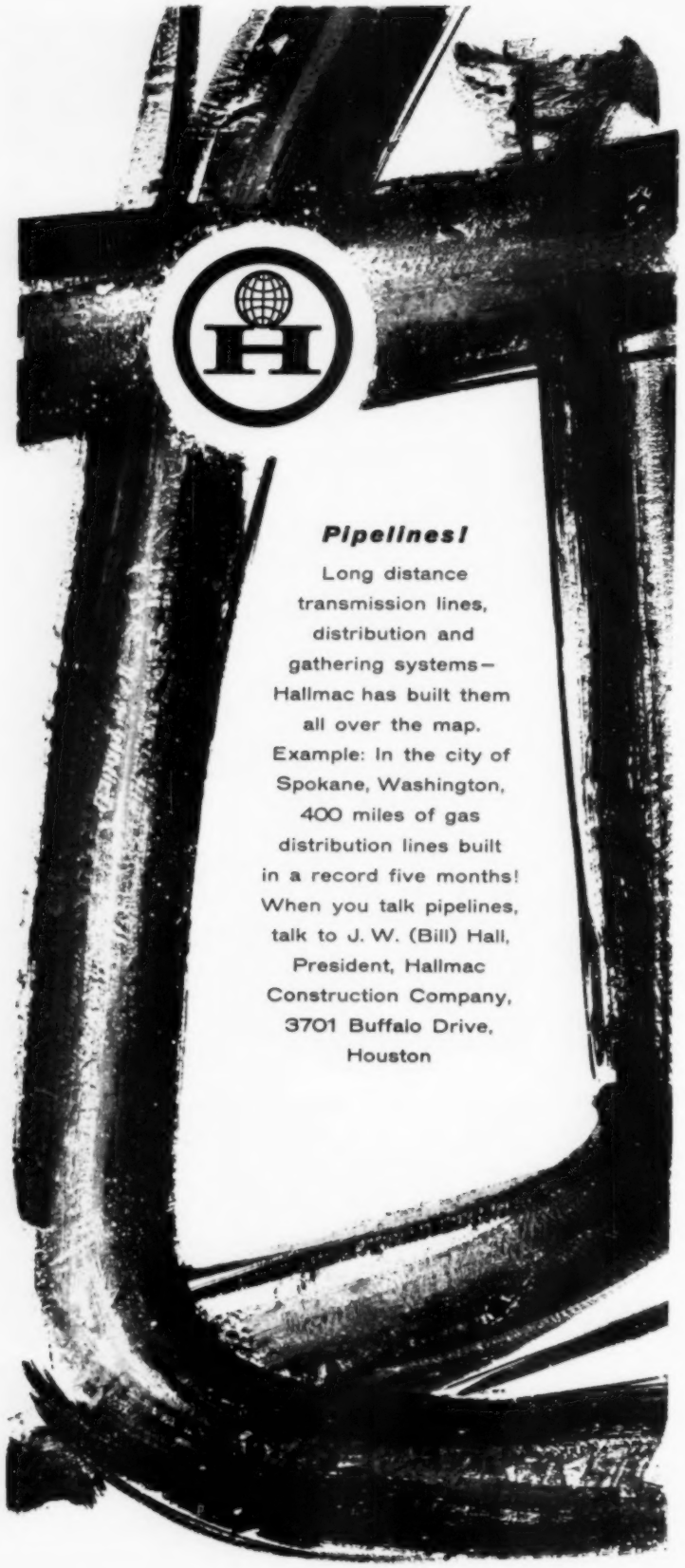
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When you talk pipelines, talk to J. W. (Bill) Hall, President, Hallmac Construction Company, 3701 Buffalo Drive, Houston

PIPELINE PERSONALS

▸ **John M. Kindle** has been named vice president in charge of transmission for Lone Star Gas Company and vice president and director of Lone Star Producing Company, succeeding **Julian L. Foster** who has retired.

Kindle joined Lone Star 33 years ago. Since 1954 he has served as superintendent of operations in the transmission division and gas supply division of Lone Star Gas Company and Lone Star Producing Company, and prior to that was superintendent of the gasoline department of both companies.

John M. Kindle

Julian L. Foster

Foster began his career with Lone Star in 1918. He participated in the planning or actual supervision of a great portion of Lone Star transmission and gathering pipelines now totaling some 8000 miles and also gasoline plants, compressor stations, dehydration plants, desulfurization plants and city gate stations.

W. H. (Buck) Royal

▸ **W. H. (Buck) Royal** has been appointed manager of the Denver office for M. J. Crose Manufacturing Company, Inc., manufacturer of pipeline construction equipment. Royal will have jurisdiction over Crose sales-service activities throughout the entire western United States, according to **T. J. Behrenfeld,** vice president and sales manager.

Robt. D. Slack

▸ **Robert D. Slack** has been appointed sales representative for the Iowa, Nebraska, Kansas, and Missouri area for Midwestern Pipe Line Products Company, distributor for pipeline wrapping materials and other pipeline equipment.

▸ **Charles C. Whittelsey,** president of Ford, Bacon & Davis, Inc., engineers and business consultants, has been elected chairman of the board succeeding **Everett S. Coldwell,** who has retired after 33 years of service with the firm. Whittelsey will continue as president and chief executive officer.

Coldwell joined the firm in 1926. He was elected a vice president in 1941, a director in 1942, and president 10 years ago.

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The New Pipeline Equipment

Dope Kettle Unveiled

The new model "SPC" pipeline dope melting kettle, in sizes of 10 to 30 bbl capacities, features twin agitation of the filler by a hydraulic-driven sweep and

mechanically powered propeller, new side stacks which increase the heating surface area to 95 sq ft, fiber insulation for holding in the heat longer, a pressurized fuel tank, low pressure (diesel or kerosine) burner, air-cooled engines, and is mounted on tracks or skids. *Crutcher-Rolfs-Cummings, Inc.*

Circle number (81) on reply card.

Cleaning-Wrapping Machine

Only 7 men can apply 18,000 ft of tape in eight hours with a new combination cleaning and wrapping machine for 4-12 in. pipe. *Tejas Plastics Material Supply Company.*

Circle number (82) on reply card.

Hand Cutting Torches

New injection-type hand cutting torches for use with propane and natural gas have an "ease-on" cutting oxygen valve which is particularly helpful in hole piercing, rivet washing and stay bolt cutting. The Airco 2000 Series also features machined silicon bronze forging head, and brass gas tubes in a triangular arrangement. Inlet connections will accommodate ¼-in., 5/16-in. or ⅜-in. hose. *Air Reduction Sales Company.*

Circle number (83) on reply card.

Butterfly Valve In 125-Lb Size

A new full-size range of 125-lb tight-closing butterfly valves, ideal as replacement valves, for pressure reducing and throttling functions, pump discharge, and altitude storage control, has been announced. For line size ranging from 4-in. to 48-in., they are lightweight, compact, can be supported by the line, and can be buried without a vault. Shaft is one piece stainless steel. *B-I-F Industries, Inc.*

Circle number (84) on reply card.

Portable Recorder For Water Crossings

Contractors laying underwater pipelines will be interested in a new depth recorder. With five ranges of 60 ft each, its accuracy is guaranteed within 2 percent and the unit will record depths ranging from 2 to 300 ft. Total weight of the recorder and case that houses the transducer, connecting cable and sectional tube for immersion of the transducer is only 66 lb. It is completely portable. *Bendix-Marine.*

Circle number (85) on reply card.

Gas Flowmeter

A new industrial gas flowmeter, which is constructed of stainless steel for 1500 psi working pressure, has been announced to handle many types of gases. Based on the new "Vortex-Velocity" principle of flow meaurement, the meter totalizes 10 to 100 cu ft of gas per min, at line conditions, representing 1,000,000 to 10,000,000 std cu ft per day at 1000 psig. Meter is linear in operation, has a low-pressure drop, requires no auxiliary equipment, is entirely self-contained, non-electrical, and accurate to one-half of one percent. *Rotron Controls Corporation.*

Circle number (86) on reply card.

2-Inch High-Pressure Field Regulator Added

A new 2-in. high-pressure field regulator has been added to Rockwell Manufacturing Company's "141" line of regulators which are useful along isolated gas transmission lines where industrial and domestic consumers requiring small volume service must tap the lines directly. The simple, lightweight regulators are specially designed to handle the primary cuts in pressure. The new regulator has a working pressure of 1500 psi, and interchangeable orifices and springs to provide outlet pressures ranging from 5 psi. *Rockwell Manufacturing Company.*

Circle number (87) on reply card.

Pipe Cutting Attachments

Improvements in the design of two attachments for standard H&M pipe cutting and beveling machines have been announced. The Shape Cutter attachment, designed to cut various shapes of pipe intersections automatically, has been completely remodeled. Added to the Out-of-Round attachment is a new, free-wheeling roller assembly that turns a full 360 deg. *The H&M Pipe Cutting and Beveling Machine Company.*

Circle number (88) on reply card.

New Pipe Wrap Tape

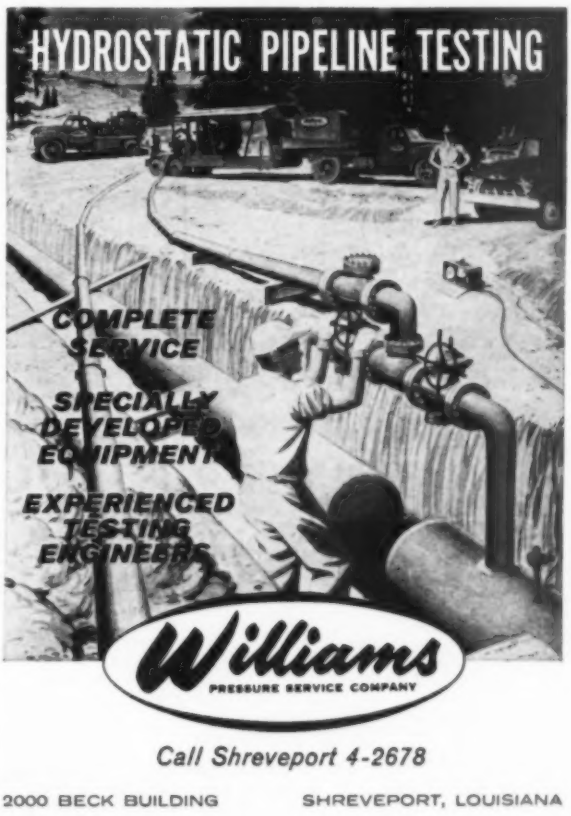
A new polyethylene pipe wrap tape is 12.5 mils thick, resistant to water, acids, alkalies, solvents, salt water, oil and fungus growth, works over a pipe temperature range from minus 30 F to plus 180 F, and can be applied to pipes by means of any type automatic pipe wrapping machinery. Positive adhesion and balanced roll release provide high adhesion to its own backing, thus permitting narrower overlap settings. *Permacel.*

Circle number (89) on reply card.

New Diesel-Driven Generating Plants

A new series of water-cooled, diesel-driven, electric generating plants, available in either 10,000 or 15,000-w a-c size ranges and in all standard 60 and 50 cycle voltages to 460 v, is announced. These self-contained generating sets will provide full-rated electric power for both primary power applications for contractors — anywhere a continuous source of electricity is needed — and all types of emergency standby power applications where low-volatile diesel fuel is preferred over gasoline. *D. W. Onan & Sons, Inc.*

Circle number (90) on reply card.



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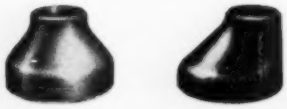

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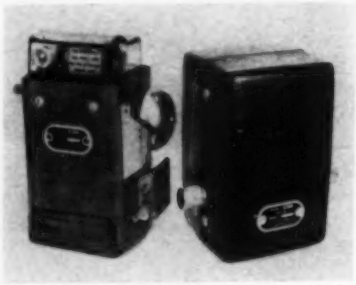
New Equipment

Holiday Detector Improved



The Tinker & Rasor Model M-1 holiday detector, left, has been redesigned to increase its usefulness and life in service. The new model, right, to be available early this year, is housed in a 2-color heavy, durable plastic case. Signal bell and relay are now totally enclosed and the bell battery comprises two standard flashlight batteries which are always available. *Tinker & Rasor.*

Circle number (91) on reply card.

Integrator Kits

A chromatograph integrator has been introduced that automatically records on a strip chart up to 12,000 counts per min per in. of chart. It is easy to read. It features a new miniature integrator, accurate to 0.1 percent full scale. Mechanism is run immersed in oil for long life. Kits are now available for Brown "Electronik," including the 1 sec, and Bristol "Dynamaster recorders." *Disc Instrument Company.*

Circle number (92) on reply card.

Digital Voltmeter

An all electronic transistorized digital voltmeter, primarily intended for automatic measurement, display, and recording of voltages in digital form and ideally suited for telemetry and alarm monitoring, has been introduced. Accuracy and resolution is 0.015 percent over the 3 automatically switched ranges of ±10, ±100, and ± 1000 v d-c. Input impedance of the instrument is 10 megohms at all times, even when digitizing and under conditions of overload. *Beckman Instruments, Inc.*

Circle number (93) on reply card.

New Crane-Excavators

A redesigned line of ⅜-yd crane-excavators, Series 350 Bantams, include a new turntable design featuring a combination hook and trunnion roller design offering fewer parts and Continental F-209 gasoline engines adding approximately 14 percent more horsepower. Carrier-mounted model T-350 and self-propelled model CR-350 feature full 11-ton lifting capacity, and the crawler-mounted C-350 has up to 8 tons lifting capacity. A wide assortment of attachments are available. *Schield Bantam Company.*

Circle number (94) on reply card.

Combination Pin-Pad Boom Connection

A new combination pin-pad boom connection is now standard equipment on the Koehring 15, 20, and 45-ton crawler models and 25, 30, and 35-ton truck crane models. According to the manufacturer,

less time is required for moves to new jobs and unfolding of the boom with this new connection. Lugs on the boom allow folding at any joint for transportation. *Koehring Division.*

Circle number (95) on reply card.

THE NEW MINIATURIZED

WILKINSON Line Locator Model W-3

This radically new, powerful transistorized sub-surface locating instruments weighs only four pounds and is one-fourth the size of conventional pipe locators.

It's as handy as a flashlight; the transistors will rarely ever require replacing; non-leak mercury cells will last at least ten times longer. The maintenance is trivial. Molded glass fibre instrument cases insure maximum protection. The aluminum connecting handle telescopes to 17" and the entire instrument is packed in a substantial carrying case.

WILKINSON PRODUCTS COMPANY

3987 Chevy Chase Drive, PASADENA 3, CALIFORNIA. SYlvan 0-4314

Piston Operator Gives Higher Stroking Speeds

A new high-pressure pneumatic piston operator, designed primarily for applications where more force and higher stroking speeds are required, has been released. Including an enclosed positioner mounted on the cylinder, suitable for a wide range of instrument signals, it operates on any supply pressure up to 150 psi, creates stem forces from 1500 to 12,000 lb, and has stroking speeds ranging up to 1.5-in. per sec. The unit is easily reversible in the field and includes a weatherproof housing over the positioners and pressure gages. *Fisher Governor Company.*

Circle number (96) on reply card.

Turbulence Controlled

Two new heavy-duty diesel engines have been introduced, featuring a new "two stage controlled turbulence" combustion and full pressure lubrication. The 21,000 is turbocharged, develops 340 hp at 2000 rpm, and is available on Allis-Chalmers HD-21 crawler tractors. The 16,000 naturally aspirated engine develops 230 hp at 2000 rpm, and powers the company's HD-16 crawler tractor and TS-260 motor scraper. Both 6-cylinder, 4-cycle, in-line engines — with 5¼-in. bore, 6½-in. stroke, 844 cu in. displacement and 14.5 to 1 compression ratio, also are available as 130 kw to 200 kw standby generator sets, for marine purposes, off-highway vehicles, power units, and other heavy-duty service requirements. *Allis-Chalmers Manufacturing Company.*

Circle number (97) on reply card.

Alarm System Monitors Pumping, Microwave Stations

A new Fault-Finder alarm system with solid state components and no moving parts has been developed for monitoring operations such as pipeline pumping stations and unattended microwave repeater stations. A transistorized ring counter scanner monitors up to 20 separate items at a scanning rate of 10 points per sec. Only one communications channel is required, plug-in circuit boards make system expansion easy, a typical receiving unit is 18-in. long, 4⅜-in. wide, 8¾-in. high, and the transmitter unit has the same dimensions except for a length of 15-in. *Applied Science Corporation of Princeton.*

Circle number (98) on reply card.

Data Logging System

"April" (Automatically Programmed Remote Indication Logging) is a new adjunct to supervisory control equipment. It can be incorporated as part of a new supervisory system or added to existing General Electric equipment, can be used on its own channel or used on the supervisory channel when required. "April" converts analog-type quantities to a binary code form and transmits the information from a remote location. When received at a master station, the code is converted to decimal form for visual display or logging using an electric typewriter. *General Electric.*

Circle number (99) on reply card.

Larger Tractors, Life-Time Lubricated

Two completely new Caterpillar D8 tractors have been announced. The Series H D8 direct drive weighs 47,102 lb, 4377 more than the previous D8. In torque converter models, the 47,875-lb weight is 4480 lb greater than the old machine. Dimensionally, they are 9 in. longer, 5 in. higher; gage has been increased to 84 in.; length of track ground contact to 114 11/16 in.; ground clearance has been increased more than 50 percent; flywheel horsepower has been increased to 225; the new engine has newly-designed manifolding; the undercarriage features "lifetime lubricated" rollers and idlers. *Caterpillar Tractor Company.*

Circle number (100) on reply card.

DESTINATION: TOMORROW!
TODAY THE E/4 SHOULDER HOLIDAY DETECTOR AND THE E/P PULSE TYPE DETECTOR FOR DAMP CLIMATES ARE ANSWERING THE PIPELINERS NEED FOR A DEPENDABLE, FULLY PORTABLE, GENERAL PURPOSE ELECTRICAL INSPECTION INSTRUMENT.
BOTH MODELS CAN BE USED FOR A FULL DAY WITHOUT RECHARGING THE BATTERY. ALL WRAPPED SURFACES INCLUDING PIPE CAN BE QUICKLY AND ACCURATELY INSPECTED FOR VOIDS, PINHOLES, BREAKS, SCRATCHES AND BURNED OR COKED SPOTS
TOMORROW THESE SAME DETECTORS WILL BE USED IN THE INSPECTION OF TUBING ON OUTER SPACE ROCKETS, FOR TINKER & RASOR DETECTORS ARE DESIGNED FOR THE FUTURE.
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TINKER & RASOR
617 AGOSTINO ROAD, P. O. BOX 281, SAN GABRIEL, CALIFORNIA

NEW PIPELINE LITERATURE

New Control Concept

A new control concept for pipeline systems is described in a recently-prepared 4-page brochure. Methods of determining and providing the type of centralized control systems required to meet present and future needs are presented. *Union Switch & Signal, division of Westinghouse Air Brake Company.*

Circle number (101) on reply card.

Mechanical Filters

A new 16-page illustrated catalog describing the complete line of standard production Collins Mechanical Filters has been issued. *Collins Radio Company.*

Circle number (102) on reply card.

More Compressor Horsepower

A bulletin describes the new Cooper-Bessemer Series Turbocharged type GMWC compressor unit as providing 40 percent increase in horsepower and a fuel consumption of only 6900 Btu per hp-hr. Other performance features are outlined. *The Cooper-Bessemer Corporation.*

Circle number (103) on reply card.

Welding Fittings, Flanges

Recently issued technical bulletin FDC-254 is one of a series of 25 cataloging by size, dimensional and physical data B&W welding fittings and forged steel flanges. *The Babcock & Wilcox Company.*

Circle number (104) on reply card.

Free Books for Recording Equipment Time-Cost

To assist owners in determining the cost of owning and operating equipment, Caterpillar Tractor Company is making available at no cost a special 24-page "Monthly Time and Cost Record Book" and a pocket-size "Daily Time and Cost

Record Booklet." In the former, 12 sets of pages are included on which to record, day-by-day, each month's individual machine expenses for an entire year, including quantity and cost of diesel fuel, gasoline, lubricating oil, grease, filters, hydraulic oil, repair labor, and operator's time. The pocket-size booklet may be used to record expenses as they occur in the field, for transfer later to the monthly cost record book. *Caterpillar Tractor Company.*

Circle number (105) on reply card.

Antenna Systems, Transmission Lines

The Andrew Corporation product line covering radio antennas for communications and broadcasting and transmission lines used to interconnect radio frequency equipment is described in a new catalog. To assist the engineer in planning antenna systems, the catalog employs comprehensive product descriptions, illustrations, and new product applications. An antenna selection chart and a transmission line selection chart are included. *Andrew Corporation.*

Circle number (106) on reply card.

Air Compressors In Three Models

Three models of air compressors, G single-stage, YS single-stage, and YC two-stage, described as featuring low oil level protection, enclosed crankcase, controlled pressure lubrication, and thermal overload protection, are featured in a new, 4-color, 12-page bulletin. Comprehensive specifications list cu ft per min displacements, pressures, weights, dimensions, and rpm of the various models and sizes. Component parts and accessories are explained, and a section of the bulletin is devoted to air receiver and auxiliary storage tank specifications and dimensions. *Le Roi Division, Westinghouse Air Brake Company.*

Circle number (107) on reply card.

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New Literature

Hydraulic Drives For Cooler Fans

A color brochure has been issued describing hydraulic drives for aerial cooler fans at pipeline compressor stations, with illustrations of several methods of driving fans and pumps that provide a wide range of fan speeds and horsepowers; a drawing showing the operating parts of a three-cylinder unit; diagrams showing representative circuits and drive selector graphs. Also available are reprints of a number of articles that have appeared on the subject in technical publications. *Berry Division, Oliver Iron and Steel Corporation.*

Circle number (108) on reply card.

High Tensile Electrodes

A brochure describing 2 new high tensile, low hydrogen electrodes has been issued. The Jetweld LH-90 is described as being a 1¼ percent chromium, ½ percent molybdenum electrode, intended for pressure piping or general fabrication where the joint requires the specific alloy. The Jetweld LH-110 is described as a 1½ percent chromium, ½ percent molybdenum, and 2 percent nickel electrode, intended for use on the new HY-80 and T-1 steels. Iron powder coating, high deposition efficiency, easy slag removal, and larger beads are among the features listed. *The Lincoln Electric Company.*

Circle number (109) on reply card.

Cast-Steel Gate Valves

A new catalog is announced covering the G-3 series of cast steel pipeline gate valves, which are available in 2-in., 3-in., and 4-in. sizes in the ASA series 150, 300, 400, 600, and 900. Series G-3 valves are manufactured with either flanged or welded ends which are bored and machined to customer specification. Design features described include patented Seal-O-Rings, full open conduit, double seal metal to metal plus "O" rings, and non-wedging parallel sided gate. *Grove Valve and Regulator Company.*

Circle number (110) on reply card.

Remote Reading Liquid Level Gages

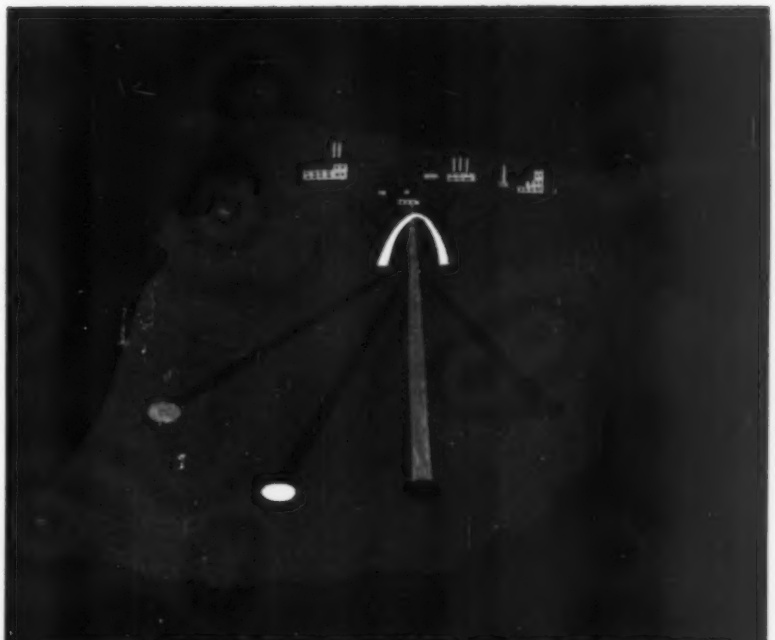
Gages for remote liquid level indication for boilers, deaerating vessels, boiler feed water tanks, and storage tanks are described in a new 8-page, 3-color catalog. Detailing the complete line of Jerguson Truscale Gages, the catalog gives information on the various styles and models, and datum columns that simplify selection for specific requirements. Operation, application data, and accessories are explained in detail. *Jerguson Gage & Valve Company.*

Circle number (111) on reply card.

Dielectric Measurements Instruments Described

The principle of operation of the Cut Point Model 150-P capacitance type pipeline interface detector, its specifications, and a typical installation are described in a new bulletin. Another bulletin describes the Monitron — designed to continuously monitor the crude oil being delivered to the pipeline and to recycle it through the treaters when the BS&W exceeds a predetermined acceptable percentage. *United Engineers, Inc.*

Circle number (112) on reply card.



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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

New Literature

Temperature Transmitter With Range Versatility

The Taylor Sensaire temperature transmitter is of particular interest to anyone with low cost temperature measurement requirements in the minus 30 F to plus 1200 F range, according to a bulletin giving design and operation information and specifications on the instrument. All models are described as being continuously adjustable over a wide range of temperatures and being easily adaptable to new ranges, new applications — in the field — by installing a pre-calibrated thermal system. A universal type mounting bracket permits installation almost anywhere: On flat surfaces, pipelines, or pipe hangers. *Taylor Instrument Companies.*

Circle number (113) on reply card.

Compressor Advances

"New Horizons In Compressor Design and Pipeline Technology" presents 5 new advances increasing the operating efficiency of reciprocating pipeline compressors. Described are: New low ratio compressor cylinders; new maintenance-free, poppet-type valves; use of electronic "brain" to calculate performance and eliminate guesswork; development and use of a unique analog computer to calculate header sizes for optimum flow; and new advances in control and automation. The bulletin also introduces a new concept for rating and comparing compressors, i.e., measuring fuel consumption per million std cu ft per day of gas compressed. *Clark Bros. Co., division of Dresser Industries.*

Circle number (114) on reply card.

Free . . . Circular Slide

This convenient, pocket-size slide rule is made available free to engineers and other plant and office executives. Operation of the rule is simple, and results are said to be accurate. Complete easy-to-follow instructions are included with each slide rule. *General Industrial Company.*

Circle number (115) on reply card.

Regulator Catalog

A new 36-page catalog of cylinder, manifold, and station pressure regulators has been made available. The illustrated booklet contains flow and pressure specifications, as well as inlet and outlet connection dimensions, for each regulator. Adapters, station valves, flowmeters, hose connections, and pressure gages are also described in detail. *Air Reduction Sales Company.*

Circle number (116) on reply card.

Prospectus For Microwave Standards Measurements

A 36-page application, "Microwave Standards Prospectus" describes the latest techniques and instrumentation for making various microwave standards measurements, including frequency, attenuation, impedance and power. It contains typical measuring arrangements, with many system block diagrams and accuracy curves, and includes a detailed list of the latest equipment available for standards measurements. *Hewlett-Packard Company.*

Circle number (117) on reply card.

Condensed Catalog of Pipe, Fittings, Flanges

An aid to pipe users is a condensed catalog of pipe, fittings, flanges, and connections. Standard specifications for Naylor Lockseam Spiralweld pipe in 4-in. to 30-in. sizes are presented, as well as illustrated data on the manufacturer's one-piece Wedgelock couplings, other types of connections, standard fittings for lightweight pipe and welding flanges. Applications are presented in concise form. *Naylor Pipe Company.*

Circle number (118) on reply card.

Floodlight Catalog

Descriptions and listings of floodlights, searchlights, and special lighting equipment are contained in a new looseleaf catalog. Colored divider sheets with individual tables of contents aid in selection for specialized lighting such as for hazardous areas and under water. *Crouse-Hinds Company.*

Circle number (119) on reply card.

PIPELINE PIONEER

The Original Vertical Pipe Bending Machine
Still Leads The Way . . . And Here's Why!

SPEED — Already the fastest bending machine, the CRC bender is now faster than ever with a new reversing clutch for equal speed forward and reverse in all four forward gears. You touch only one lever to raise and lower the pipe. A new torque converter gives a smoother power flow and more speed without shifting transmission.

SMOOTH, WRINKLE-FREE BENDS — Plenty of power on hand to pull smooth, non-wrinkling bends in the strongest pipe made. Flattening or egging of pipe walls held to absolute minimum.

NEW, NARROW WIDTH — CRC Model "B" bending machines are now under eight feet wide in the 20", 30", and 36" sizes for direct truck transporting to your job site. Tracks or rubber tires optional on all machines.

LOWEST MAINTENANCE — The mechanical, cable-operated vertical pipe bender stands alone as the most economical, trouble-free bending machine in use . . . no costly shut-downs due to parts failure, and no expensive mechanisms to replace.

Depend on CRC bending speed, accuracy, and ruggedness to get your job done *on time* day after day. Protect your investment with the pioneer of pipe benders, the CRC Vertical Pipe Bending Machine.

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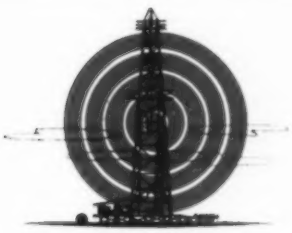
Rig Locator

supplement to

the Petroleum Engineer



SPRING 1959

An exclusive summary of contract drilling rigs . . . rotary and cable tools . . . and well servicing rigs. It is INTERNATIONAL in scope and includes rigs working offshore

4th Anniversary Edition

DRILLING RIG LOCATOR

This 11th edition shows many changes in companies, equipment and their location. Many adjustments have been made by contractors everywhere since the Fall RIG LOCATOR was published last October. An increase is noted in the number of foreign rigs listed and there are more servicing contractors and rigs listed than ever before

The last six months period has been a tumultuous one for the drilling and servicing industries. They have sold, junked and otherwise disposed of many more rigs since the Fall RIG LOCATOR was sent to you last October. Many more rigs are operating in foreign lands and here are some of the countries listing increases: Australia, Argentina, Bolivia, Brazil, Cuba, Denmark, Italy, Mexico, Guatemala.

Drilling contractors have been modernizing and making their equipment more efficient and have sought out the active areas to locate additional or new equipment. Servicing contractors have likewise consolidated their positions to increase their ability to operate more efficiently and serve their customers better.

There have been spurts of higher drilling and servicing activity during this period and there are indications of a substantially higher level of activity for 1959. There are two factors then, to make this 11th issue of the RIG LOCATOR of valuable use to all those concerned with the drilling and well servicing industries. One, the recording of the many changes in companies and their equipment. Two, the prospect of a more active year which will stimulate the use of the RIG LOCATOR by those important people, customers, who need a good rig for their job and want to know where it is now located. We are glad to report that a greater percentage of contractors everywhere are responding to *The Petroleum Engineer's* offer to list their rigs at no cost to them. We have also been encouraged by many messages of appreciation from the producers who are using the RIG LOCATOR more often to find the equipment they want and where it is located. Mr. Contractor, if your equipment is not listed in this issue, be sure to get it in the next one. And Mr. Producer, if you are needing more copies of the RIG LOCATOR please let us know . . . we will supply same, gladly. We shall also appreciate helpful comments from any of the RIG LOCATOR users on how it can be improved to serve you better.

Use of abbreviations. In a directory of this type where certain specifications are included, it was necessary in the conservation of space to make some abbreviations. Under the column of "type power," the following abbreviations apply: Dsl for diesel; gaso for gasoline; stm for steam; btne for butane; and dsl elec for diesel electric. In listing drawworks make and model number, it was necessary to abbreviate the manufacturer's name. Some of these abbreviations are well known; others had to be made to fit the available space. Here's the code we used:

Manufacturer's Company Name	Abbreviation
ALCO Products, Inc. (formerly Beaumont Iron Works Div. of American Locomotive Co.)	ALCO-BIW
Allis-Chalmers Manufacturing Co.	Allis Chmrs
American Iron & Machine Works	Amer
Ansaldo	Ansaldo
Bethlehem Supply Co.	Beth
Big Four Machine & Supply Co.	Big Four
Border Foundry & Machine	Border
The Brewster Co., Inc.	Brwstr
Bucyrus-Erie Co.	B. Erie
Cardwell Manufacturing Co., Inc.	Crdwll
Clark Bros. Co., Inc.	Clark
Fred E. Cooper, Inc.	Cooper
Continental-Emsco Co.	Emsco
Cummins Engine Co., Inc.	Cummins
George E. Failing Co.	Failing
Franks Division of Cabot Shops, Inc.	Frnks
General Machine Co.	Gen Mach
Hacker Machine & Supply Co.	Hacker
Hopper Machine Works, Inc.	Hopper
Houston Tool Co.	Hou
Howard-Turner Machine Works	Howard-Turner
Ideco, Inc.	Ideco
Ingersoll-Rand Co.	Ingersoll
Jones, Shelburne & Guffey Co.	JS&G
Joy Manufacturing Co.	Joy
Lucey Export Corp.	Lucey
Mayhew Supply Co., Inc.	Mayhew
Mid-Continent Supply Co., Inc.	M-CSCO
Lee C. Moore Corp.	L. C. Moore
Muskogee Iron Works	MIW
The National Supply Co.	Natl
Oil Well Supply Division (U. S. Steel Corp.)	"Oilwell"
Reich Bros.	Reich
Spencer-Harris Machine & Tool Co.	Spencer
Stardrill-Keystone Co.	Star
Texas Iron Works, Inc.	TIW
Vickers, Inc.	Vickers
Victoria Machine Works	Vic
Wagner-Morehouse, Inc.	Wgnr-Mrhse
Walker-Neer Manufacturing Co., Inc.	Wlkr-Nr
Waldrip Engineering Co.	Wldrp
Well Machinery & Supply Co., Inc.	Ft. Wrth
Wheeling Machine Products Co.	Wheeling
The Wheland Co.	Whlnd
Wichita Tool Supply Co.	Wich
Wichtex Machinery Co., Inc.	Wichtex
Wilson Manufacturing Co., Inc.	Wlsn

The Petroleum Engineer's March 1959

DRILLING RIG LOCATOR

Including U. S. and Canadian Well Servicing Units

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U. S. Drilling Contractors

ROTARY AND CABLE TOOLS

ALPHABETICAL LISTING

A

A & P Drlg Co Inc Box 568 Duncan Okla
Ace Drlg Co 1800 Republic Natl Bk Bldg Dallas Tex
Adkins Drlg Co 1517 Milam Bldg San Antonio Tex
Akin & Dimock 714 Holliday St Wichita Falls Tex
Alan Drlg Co 807 Oil & Gas Bldg Wichita Falls Tex
Allen & Morris 820 Alamo Natl Bldg San Antonio 5 Tex
Allen Drlg Co 4410 Venable Ave Charleston 4 W Va
B F Allison Drlg Co 626 Patterson Bldg Denver Colo
Anderson Drlg Co 730 Wichita Natl Bk Bldg Wichita Falls Tex
Anschutz Oil Co Inc Box 1466 Casper Wyo
Appell Petroleum Corp Box 330 Alice Tex
Ari-Kan Drlg Co Box 162 Great Bend Kans
Arrow Drlg Co 407 Philtower Bldg Tulsa Okla
Ashby Drlg Co Ltd 738 Meadows Bldg Dallas 6 Tex
Ashton Well Serv Box 541 Iowa Pk Tex

B

B & B Drlg Co Whitlash Mont
B J & M Drlg Co Ltd 160 S Fairfax Ave Los Angeles Calif
Baird & Pfeifer Drlg Co 316 Kittredge Bldg Denver Colo
Darris Ballew Inc Box 561 Natchez Miss
Bar-Lee Drlg Co Box 7264 Tulsa Okla
Barnes Core Drlg Co 1350 Roberts Ln Bakersfield Calif
Barrett Petroleum Co 423 Masonic Bldg Shawnee Okla
Barry Well Drlg Co West Star Rt Fallon Nev
Robert M Bass Drlg Contr Box 471 Kilgore Tex
Beardmore Drlg Co 827 Beacon Bldg Wichita Kans
Bennett Drlg Co 1381 E 26th St Tulsa 14 Okla
Bernhardt Drlg Co 2469 Grand River Detroit 1 Mich
Berry Drlg Co Box 67 Saint Jo Tex
Big Chief Drlg Co Box 8837 Oklahoma City 14 Okla
Big Horn Drlg Co Inc 117 N Beech Casper Wyo
Big Seven Drlg Co 311 Wright Bldg Evansville Ind
Big '6' Drlg Co 225 Oil & Gas Bldg Houston 2 Tex
Big West Drlg Co 1505 Oil & Gas Bldg Ft Worth 2 Tex
Big X Drlg Co Inc 2905 First Natl Bldg Oklahoma City Okla
Bill's Drlg Serv 617 Union Natl Bldg Wichita 2 Kans
Black Drlg Co 525 Petroleum Bldg Abilene Tex
Henry Black Drlg Co Inc Box 174 Midland Tex
Forest Blackstock Inc V & J Tower Bldg Midland Tex
Bodard Drlg Co 313 Masonic Bldg Shawnee Okla
Bolin Oil Co & D H Bolin 1120 Oil & Gas Bldg Wichita Falls Tex
Boyd & Durst Drlg Contr Box 329 Alice Tex
Brannon & Murray Drlg Co Box 672 Coleman Tex
Brantly Drlg Co Inc Box 4935 Midland Tex
Brantly Drlg Co (Intl) Inc Box 4935 Midland Tex
Branyan Drlg Co Box 166 Cushing Okla
D J Branyan Co Box 166 Cushing Okla
C E Brehn Drawer 618 Mt Vernon Ill
Brewster-Bartle Drlg Co Inc 1919 Bk of Southwest Bldg Houston
Zach Brooks Drlg Co Box 31 El Dorado Ark
Brown Drlg Co Box 7217 Long Beach 7, Calif
Brown & Martin Drlg Co Box 731 Gainesville Tex
Brown & Thorp Drlg Co Box 1358 McCamey Tex
Tom Brown Drlg Co Box 5131 Midland Tex
Layton Brown Drlg Co Box 185 Woodsboro Tex
Bryant-Hayward Drlg Co Box 4627 Oklahoma City Okla
Harry T Bryant Drlg Co Ltd Box 13364 Houston 19 Tex
Bueno Drlg Co 207 Continental Oil Bldg Denver Colo
A O Bullock Drlg Co Box 821 Casper Wyo
Buick Drlg Inc 409 Wolcott Bldg Hutchinson Kans
Burger Drlg Co Box 327 Coleman Tex
Butler County Drlg Co 506 Orpheum Bldg Wichita Kans
Butler-Johnson Inc Box 306 Shreveport La
Buzzini Drlg Co Petroleum Center San Antonio 5 Tex

C

C-P Drlg Co Box 685 Pampa Tex
Cactus Drlg Corp of Tex Box 348 San Angelo Tex
Calvert Drlg Inc Box 552 Olney Ill
Camay Drlg Co 4250 Wilshire Blvd Los Angeles 5 Calif
Camay Drlg Co Rocky Mt Div Suite 1130 Denver Club Bldg Denver Colo
Camdrill International Inc c/o Camay Drlg Co 4250 Wilshire Blvd Los Angeles 5 Calif
Canadian River Drlg Co 424 Petroleum Bldg Amarillo Tex
Frank Caraway Drlg Co Box 982 San Angelo Tex
Cardinal Drlg Co (Bismarck) 420 Fourth St P O Box 446 Bismarck N D
Carey & Parker Inc 380 N Jackson Odessa Tex
Carmack Drlg Co 1008 Mile High Center Denver 2 Colo
Carpenter-Trant Drlg Co 321 C A Johnson Bldg Denver 2 Colo
Carroll Drlg Co Inc Box 337 Farmington N M
Carter Drlg Co 1640 W 34th St N Wichita Kans
Casselman Bros Drlg Co c/o C J Casselman Rt 1 Morris Okla
Central Drlg Co 704 10th St Lawrenceville Ill
Central Drlg Co Inc Box 44 Fairfield Ill
Ford Chapman Box 1512 Pecos Tex
Chiles Drlg Co Box 949 Alice Tex
Cecil Chisler & Son Route 2 Fairview W Va
Circle Drlg Co Inc 620 Pioneer Bldg Lake Charles La
R L Bob Clark Drlg Contr Box 1933 Kermit Tex
Don Clawson 125 W 19th St Ada Okla
Claypool Drlg Co Box 98 St Elmo Ill
Clegg & Hunt 715 Houston Club Bldg Houston Tex
Clinch Drlg Co Box 27 Hazlehurst Miss
Coastal Drlg Co 7300 Downing Ave Bakersfield Calif
Columbia Drlg Co 1207 C & I Life Bldg Houston 2 Tex
Comet Drlg Co Box 1143 OCS Lafayette La
Continental Shelf Drlg Corp 916 Richards Bldg New Orleans 12 La
Continental Marine Expl Co Box 3050 Houston Tex
Cooper Drlg Co 902 Staley Bldg Wichita Falls Tex
R A Cooper Drlg Co Inc 711 Hulman Bldg Evansville 8 Ind
Coreco Drlg Co 2807 Mercantile Bk Bldg Dallas 1 Tex
Crawford Drlg Co Box 622 Shreveport La
Cree Drlg Co Inc Box 1821 Pampa Tex
Jess P Cross Drlg Contr 1216 Texas Graham Tex
Crow Drlg & Prod Co 2000 Beck Bldg Shreveport La
Crow Greyhound Drlg Co Inc Box 7334 Shreveport La
Milton Crow Inc 420 Commercial Natl Bk Bldg Shreveport La
Crown Rigs Inc 2107 Bk of the Southwest Bldg Houston Tex
Cummins Drlg Co Altamont Ill

D

D & M Drlg Co Inc Box 247 Great Bend Kans
D-K Drlg Co Box 866 Cortez Colo
Danforth Drlg Co 418 Kennedy Bldg Tulsa Okla
R W Darden Drlg Co Box 576 Olney Tex
R A Davenport Drlg Contr 211 Perkins Bldg Duncan Okla
Davidson Drlg Co Inc 1004 Continental Life Bldg Ft Worth Tex
Davis & Bates Inc 1601 Milam Bldg San Antonio 5 Tex
Davon Drlg Co Box 1586 Oklahoma City Okla
M J Delaney Co 910 Dallas Fed Savings Bldg Dallas 1 Tex
Delaware Drlg Co Box 387 Pawhuska Okla
Del Mar Drlg Co 409 Oil Industries Bldg Corpus Christi Tex
Delta Drlg Co Box 2012 Tyler Tex
Delta Overseas Drlg Co (Rome Italy) Box 2012 Tyler Tex
Dillard-Waltermire Inc 109 Oil & Gas Bldg Houston 2 Tex
W L Dillier Box 341 Casey Ill
Doak Drlg Co Box 1108 Bristow Okla
Drillers Inc 2005 Adolphus Tower Dallas Tex
Drlg & Expl Co of Delaware Inc Box 35366 Dallas 35 Tex
Drilling & Production Co 2907 L St Bakersfield Calif
Dual Drlg Co 606 City Natl Bk Bldg Wichita Falls Tex
Dudley & Heath Drlg Co Box 428 Stillwater Okla
Dyer Drlg Co Box 338 Casper Wyo

E

Eagle Drlg & Developing Co Box 89 Natchez Miss
Eakle & Holder Drlg Co 116 Mulberry St Evansville Ind
Eastland Drlg Co 806 Continental Life Bldg Ft Worth 2 Tex
Eatmon Drlg Co Box 535 Kimball Neb
Harry L Edwards Drlg Co Box 6825 Houston 5 Tex
King Edwards (Edwards Drlg Co) Box 1140 Graham Tex
A W Eggleston Inc Box 425 Crowley La
Errol Elkins Drlg Co 460 Rio Grande St Eagle Pass Tex
Ellis 1536 Austin St Colorado City Tex
Ellis Drlg Corp Box 393 Colorado City Tex
Empire Drlg Co 1403 Texaco Bldg Dallas 1 Tex
Empire Drlg Co 650 Fourth Natl Bk Bldg Wichita Kans
Enterprise Oil Co 7440 La Hore Rd Bakersfield Calif
Ewing Drlg Co Box 807 Breckenridge Tex
Exeter Drlg Co Republic Natl Bk Bldg Dallas 1 Tex
Exploration Drlg Co 607 Natl Bk of Tulsa Bldg Tulsa Okla

F

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Falco Drlg Co Inc Box 1255 Alice Tex
Falcon Seaboard Drlg Co Pan American Bldg Tulsa Okla
Felderhoff Bros Drlg Co Box 87 Muenster Tex
C F Finefield Box 235 Wagoner Okla
Jim Fish Drlg Co Box 655 Iowa Park Tex
Fitzpatrick Drlg Co Inc Box 639 Casper Wyo
Fleeger Drlg Inc 271 Meadows Bldg Dallas 6 Tex
Folk Drlg Co 614 Main Yukon Okla
Foree Drlg Co 607 First Natl Bk Bldg Dallas 2 Tex
Fortune Drlg Corp Petroleum Bldg San Angelo Tex
Foster Drlg Co Inc Box 751 Cushing Okla
4-J Drlg and Well Serv Co Box 471 Drumright Okla
Armstrong Fowler Inc 929 Oleander Bakersfield Calif
Frio Drlg Inc 506 Driscoll Bldg Corpus Christi Tex
Fryer & Hanson Drlg Co 2520 Republic Natl Bk Bldg Dallas Tex

G

Gabbert-Jones Drlg Co Inc 514 Orpheum Bldg Wichita Kans
Gardner Bros Drlg Co Inc 1718 Davis Bldg Dallas Tex
Garr-Woolley Oil Co 901 Cravens Bldg Oklahoma City Okla
Garvey Drlg Co Route 2 Great Bend Kans
Gary Drlg Co Box 58 Oil City La
General Drlg Co P O Box 1845 Oklahoma City 1 Okla
General Geophysical Co 750 Houston Club Bldg Houston 2 Tex
Gibson Drlg Co Box 1540 Kilgore Tex
Clyde Gibson Drlg Co 712 City Natl Bank Bldg Wichita Falls Tex
Gilmour Drlg Co Box 1082 Alice Tex
Glendale Drlg Co 906 Hales Bldg Oklahoma City Okla
Glenn Drlg Co 38 Kennedy Bldg Tulsa Okla
F E Gober Drlg Co 3032 Cherry Ave Long Beach 7 Calif
Al Godfrey Drlg Co 2875 Cherry Ave Long Beach 6 Calif
Goe Drlg Inc Box 5 Perry Okla
Goff-Leeper Drlg Co Box 1749 Ardmore Okla
Goldsmith Drlg Co Box 750 Duncan Okla
Gordon Drlg Co Box 335 Mt Pleasant Mich
T V Gorman Drlg Contr 621 Staley Bldg Wichita Falls Tex
Jack Grace Drlg Co 1009 City Natl Bk Bldg Wichita Falls Tex
H O Grace Drlg Co 632 Wichita Natl Bldg Wichita Falls Tex
Gracey-Hellums Corp 410 S Coast Bldg Houston 2 Tex
Graham Drlg Co 2nd Floor, First St Bk Bldg Temple Okla
Graham-Michaelis Oil Co 211 N Broadway Wichita 2 Kans
John Grappe Drlg Co Box 1186 Levelland Tex
Graves Drlg Co Box 583 Ardmore Okla
Gray Drlg Co 220 Wichita Natl Bk Bldg Wichita Falls Tex
Graytex Drlg Co 406 Robertson Bldg Wichita Falls Tex
Guadalupe Drlg Co 2505 Princeton Ave Midland Tex
Roy Guffey Drlg Co 5543 Yale Blvd Dallas 6 Tex
Gulf Drlg Inc Box 398 Lake Charles La
Henry Gwaltney Drlg Co Box 289 Washington Ind

H

H & S Drlg Co 407 Tri State Ins Bldg Tulsa Okla
Hack Drlg Co Box 5108 Abilene Tex
John S Hagestad Drlg Co 3224 Gulf St Bakersfield Calif
Halbert Drlg Co 607 Citizens Bk Bldg Tyler Tex
Clyde Hall Drlg Co Inc Box 4068 Bakersfield Calif
O E Hall Drlg Co 2008 Continental Natl Bk Bldg Ft Worth 2 Tex
Hamman Oil & Ref Co Box 13028 Houston 19 Tex
Haney & Williams Drlg Co 3500 Cherry Ave Long Beach 7 Calif
Hap Drlg Co 2510 First Natl Bldg Oklahoma City Okla
F E Hargraves & Sons Drlg Co Inc Box 573 Oil City La
Harkins & Co Box 1490 Alice Tex
Dave Harlin Drlg Co 107 Bramfield Bldg Snyder Tex
Harris Drlg Co Box 699 Grayville Ill
John W Harris Drlg Co 525 Wichita Natl Bk Bldg Wichita Falls Tex
Harvey Drlg Co Box 418 Wichita Falls Tex
John Haseman Inc 419 Wilson Bldg Corpus Christi Tex
J W Hastings Drlg Co 722 Wichita Natl Bk Bldg Wichita Falls Tex
Hawkins-Wilkins Prod Co 373 San Jacinto Bldg Houston 2 Tex
Win Hawkins Drlg Co 373 San Jacinto Bldg Houston 2 Tex
Hayward Drlg Co Box 295 Enid Okla
John Heard & Co Inc 624 S Cheyenne Tulsa Okla
Helmerich & Payne Inc First Natl Bldg Tulsa Okla
The Herb Expl Co 342 Lexington Ave Abilene Tex
Herndon Drlg Co Drawer 489 Tulsa Okla
Maxwell Herring Drlg Corp 519 Blackstone Bldg Tyler Tex
B M Hester Box 2588 Wichita Falls Tex
Hewit-Gulick Drlg Co 2555 1st Natl Bk Bldg Denver 2 Colo
Highland Oil Box 263 Jasper Ind
Hilburn Industries Inc Ricou-Brewster Bldg Shreveport La
J E Hillier Box 67 Pleasanton Tex
Hissom Drlg Co 1327 Wilco Bldg Midland Tex
Holliman Drlg Co 712 Fidelity Union Life Bldg Dallas Tex
Holm Drlg Co Box 7246 Tulsa Okla
Holmes Drlg Co 1045 San Jacinto Bldg Houston Tex
Holt Brothers Drlg Co Box 236 Pampa Tex
R L Horn & Son Drlg Co Pawnee Okla
Hose-Austin Drlg Corp Box 1067 Casper Wyo
Houchins Drlg Co Box 388 Mt Carmel Ill
Hull Oil Co 214 Panhandle Bldg Wichita Falls Tex
Hunt Drlg Co Inc 634 Wilson Bldg Corpus Christi Tex
Hupp & Hume Drlg Co Box 616 Owensboro Ky
Floyd R Hyer 314 Commerce Bldg Okmulgee Okla

I

Donald T Ingling 623 First Natl Bk Bldg Wichita 2 Kans
Iran Drlg Corp Box 1528 Longview Tex
Iron Drlg Co 1206 Philtower Bldg Tulsa 3 Okla
Isern Drlg Co Box 45 Ellinwood Kans
Ivy Drlg Co 1705 Burton Way Bakersfield Calif

J

J & C Drlg Co Box 552 Refugio Tex
S W Jack Drlg Co Allegheny Ave Avonmore Pa
Charles M Jameson Box 532 Vernal Utah
Jett Drlg Co Inc Box 1832 Shreveport La
Johnn Drlg Co 711 Fair Bldg Ft Worth Tex
Johnson Drlg & Serv Co Box 3 Magnolia Ark
Johnson-Bates Drlg Co Box 425 Konawa Okla
Johnson-Gadbois Drlg Co 200 Petroleum Bldg Abilene Tex
Al Johnson Drlg Co Rt 12 Box 440 Oklahoma 15 Okla
Fred Johnson Drlg Co 2790 Cherry Ave Long Beach 6 Calif
Jonco Drlg Co Box 1214 Seminole Okla
Jones Well Serv Co Box 1547 Abilene Tex
Buck Jones Drlg Co Box 1085 McCamey Tex
J E Jones Drlg Co Box 1516 Midland Tex

K

K & E Drlg Inc 719 Union Center Bldg Wichita 2 Kans
Keating Drlg Co 510 Natl Bk of Tulsa Bldg Tulsa 5 Okla
K L Kellogg & Sons 3777 Long Beach Blvd Long Beach 7 Calif
Kelly Drlg Co Inc Box 1126 Houma La
Kendall-Davis Drlg Co Inc 201 SE 1st St Evansville Ind
Kendrick Bros 121 E Louisiana St Vivian La
Kent & Preston 425 Sayles Blvd Abilene Tex
Keoughan Drlg Co Box 9368 Fort Worth Tex
Kermac Drlg Co of Venezuela Kerr-McGee Bldg Oklahoma City Okla
Kerr-McGee Oil Industries Inc Kerr-McGee Bldg Oklahoma City Okla
Kersey & Co Box 305 Artesia N Mex
King-Phillips Inc 1109 Continental Natl Bk Bldg Ft Worth Tex
Carl B King Drlg Co of Tex Box 270 Midland Tex
Kirby Oil Ind Inc 5107 Center St Omaha 6 Neb
Kirkpatrick Oil Co 1300 N Broadway Okla City Okla
Kirkwood Drlg Co 1420 Alamo Natl Bldg San Antonio Tex
Knight Drlg Co Box 1332 Bakersfield Calif
Earl Knox Drlg Co Box 125 Coweta Okla

L

L & H Drlg Co Oil & Gas Bldg Wichita Falls Tex
L & N Drlg Co 6709 Canal Blvd Shreveport La
Ralph G Ladd Box 5 Haskell Okla
La Mance Drlg Co Box 4457 Midland Tex
Larco Drlg Co Box 3499 Jackson Miss
J W Lawrence Box 942 Conrad Mont
Roy Lawrence Drlg Co Box 306 Pawnee Okla
Layton and Newell Drlg Co 1505 Oil & Gas Bldg Ft Worth 2 Tex
Leatherwood Drlg Co Box 925 Jacksboro Tex
Lee Drlg Co 1007 Philtower Bldg Tulsa Okla
D B Lesh Drlg Co Box 505 Mattoon Ill
Lewis Bros Inc 320 Mile High Center Denver 2 Colo
Will I Lewis Drlg Co 207 Continental Oil Bldg Denver Colo
Ted Lindsay Box 190 Mt Vernon Ill
M M Lindsey Drlg Co 4748 Airline Hwy Baton Rouge La
H J Lininger Box 37 Upper Sandusky Ohio
Lin-Mour Drlg Co 1112 Oil & Gas Bldg Wichita Falls Tex
Llano Drlg Co 301 V & J Tower Bldg Midland Texas
Lohmann-Johnson Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
Charles E Long Jr Inc Box 961 Midland Tex
Longhorn Drlg Corp Box 546 Three Rivers Tex
Love-Miller Drlg Co Inc 712 Patterson Bldg Denver 2 Colo
Low Drlg Co Box 1112 Cisco Tex
Lowe Drlg Co Box 832 Midland Tex
Lunsford Drlg Co 505 Louisiana Bk Bldg Shreveport La
Lynn Drlg Co 1403 Natl Bk of Tulsa Bldg Tulsa Okla
H B Lynn Drlg Corp Box 1085 Farmington N Mex

M

MIM Drlg Corp 1401 Majestic Bldg San Antonio Tex
Mac Drlg Co Box 2972 Houston 1 Tex
Macrate Prod Co 3341 Cherry Ave Long Beach 7 Calif
Mallonee Drlg Co Inc 820 Union Center Wichita Kans
R L Manning Co 318 Continental Oil Bldg Denver Colo
Maritzky & Bibby Box 509 Homer La
Marlin Exploration Inc 836 Olive Shreveport La
M L (Mike) Marrs Drlg Co Box 985 Drumright Okla
Mast Drlg Inc Box 33 Russell Kans
M Mazzarino 104 W Broadway Centralia Ill
McAlester Fuel Co Box 210 Magnolia Ark
Gabe McCall Drlg Co Box 2068 Casper Wyo
McCalman Drilg Co Inc Box 602 Homer La
McClure Oil Co Box 147 Alma Mich
Gene McCutchin Drlg Co Box 1585 Dallas Tex
McDaniel Drlg Co 205 C A Johnson Bldg Denver 2 Colo
A D McDuffie Box 807 Wichita Falls Tex
Lottie B McFann Drlg Co 3901 Cedar Ave Long Beach 7 Calif
B L McFarland Drlg Corp 3612 W Wall Midland Tex
W H McGarr Industries Box 472 Eagle Pass Tex
J R McGill 509 Amarillo Bldg Amarillo Tex
McQueen & Stout Drlg Co 1113 Ft Worth Natl Bk Bldg Ft Worth 2 Tex
Meadows & Walker Drlg Co 500 San Jacinto Bldg Houston 2 Tex
Melco Drlg Co Box 1360 Seminole Okla
Meredith & Co 1418 Bk of the Southwest Bldg Houston 2 Tex
Ward S Merrick Box 971 Ardmore Okla
Mesker Drlg Co 1129 E 15th St Tulsa Okla
Midwestern Drillers Inc 1206 Mid-Continent Bldg Tulsa 3 Okla
Milam Drlg Co 1814 Alamo Natl Bldg San Antonio Tex
Milhoan Drlg Co Box 948 Tulsa 1 Okla
Miller Bros & Bowling Box 611 Alice Tex
Gene Miller Inc Box 238 Lawrenceville Ill
Mobile Drlg Co 705 Fourth Natl Bk Bldg Wichita 2 Kans
Mobile Drlg & Well Serv Co Inc Box 207 Conroe Tex
Monroe Drlg Co Inc Box 490 Monroe, Louisiana
Montgomery Drlg Co Box 747 El Dorado Ark
J S Montgomery 103 NW 44th St Oklahoma City Okla
Mora Drlg Co 800 Midstates Bldg Tulsa Okla
Moran Bros Inc 1200 Oil & Gas Bldg Wichita Falls Tex
Moran Oil Prod & Drlg Corp Box 1718 Hobbs N Mex
E W Moran Drlg Co 500 First Natl Bk Bldg Wichita Falls Tex
Dave Morgan Drlg Co Box 820 Blackwell Okla
Pete Morris Drlg Co Box 733 Ada Okla
Morrison Drlg Co Inc Box 583 Casper Wyo
Dale Mount Drlg Inc 1155 Mercantile Dallas Bldg Dallas 1 Tex
Mountain States Drlg Co Inc 622 Patterson Bldg Denver 2 Colo
Movible Offshore Co 743 San Jacinto Bldg Houston 2 Tex
Murfin Drlg Co 617 Union Center Wichita 2 Kans
Murphy & McKernan Box 169 Pampa Tex
Musgrove Petroleum Corp 801 Union Center Wichita Kans
Muskegon Development Co 432 Lyman Bldg Muskegon Mich

N

Neal Drlg Co Box 3186 Victoria Tex
Needham Drlg Co Box 1285 Artesia N Mex
Nelson Spain Drlg Co 300 W Main Ardmore Okla
Nemaha Oil Co Mercantile Bk Bldg Dallas Tex
Newton Drlg Co Box 1104 Coalinga Calif
Nicklos Drlg Co 518 First City Natl Bk Bldg Houston 2 Tex
The Noah Petroleum Co Box 192 Albion Ill
Norman Drlg Corp 1141 Butternut St Abilene Tex
Norton Drlg Co 542 Natl Bk of Commerce Bldg New Orleans 12 La
The Novak Drlg Co Box 2147 Tulsa Okla
Nuckolls-Bell Drlg Co 1255 First Natl Bldg Oklahoma City 2 Okla
Nye & Snell Drlg Co 208 Patterson Bldg Denver Colo

O

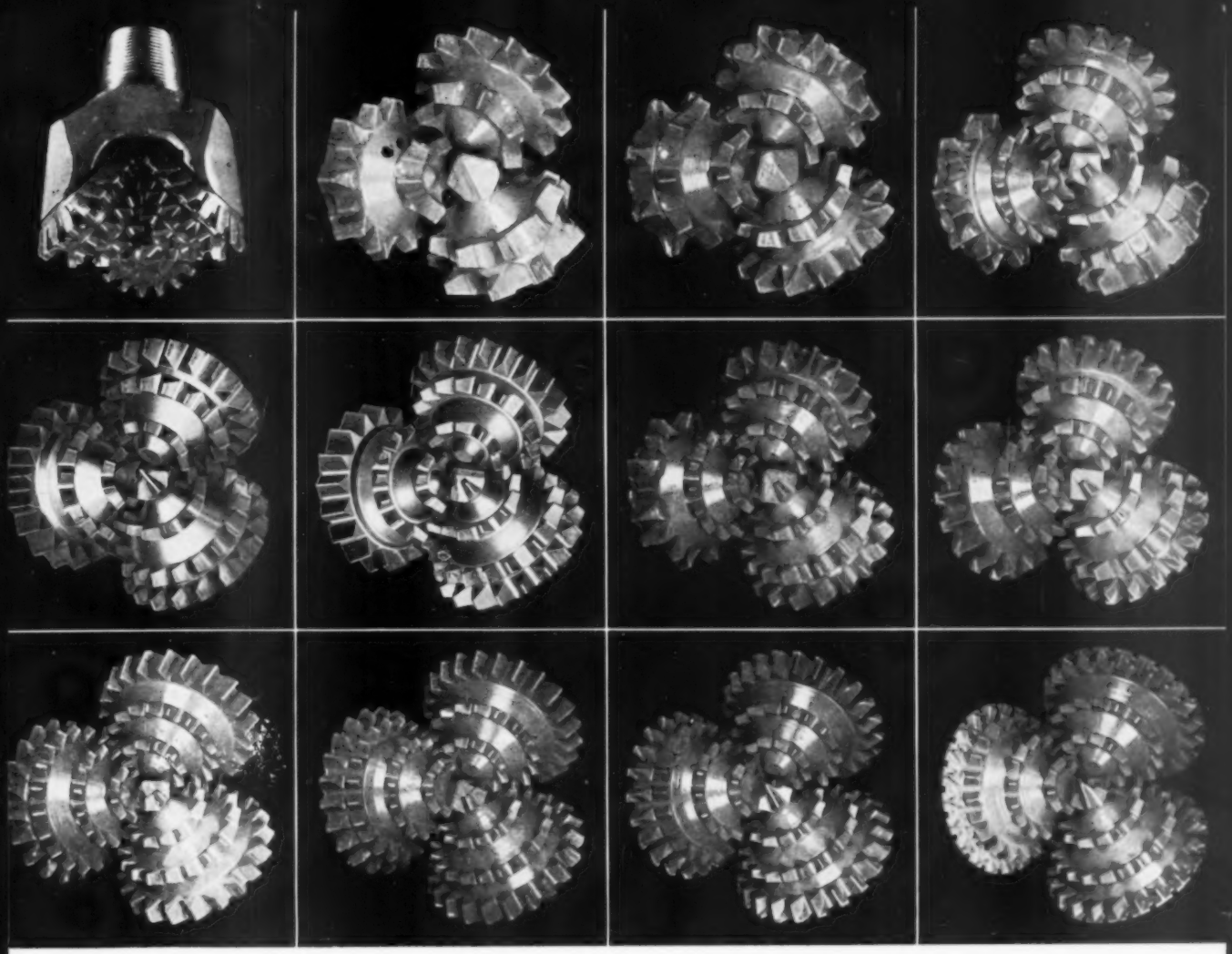
Davey O'Brien Drlg Co Inc 615 Ft Worth Club Bldg Ft Worth Tex
Oien Oil Corp Box 2235 Cut Bank Mont
Olds & Wrather Drlg Co Box 113 Casper Wyo
W B Omohundro Box 774 Wichita Falls Tex
Oney Drlg Co Box 425 Graham Tex
Orm Drlg Co 421 M & P Bk Bldg Sherman Tex
O'Rourke-McGirl Drlg Co 632 Natl Bk of Tulsa Bldg Tulsa Okla
Overby Drlg Co Inc Box 248 Nowata Okla
Owen Drlg Co Box 1423 OCS Lafayette La

P

Paine Drlg Co 301 Insur-O-Medic Bldg Dallas Tex
Pan-Tex Drlg Co 316 Henderson Blvd Kilgore Tex
Parker Drlg Co 418 Natl Bk of Tulsa Bldg Tulsa 3 Okla
Howard Parker Co 1103 Bk of Southwest Bldg Houston 2 Tex
Patton Drlg Co Inc Orpheum Bldg Wichita Kans
Patco Drlg Contr Box 322 Stillwater Okla
Payne Bros Drlg Co 611½ 12th St Box 15 Lawrenceville Ill
Peak Drlg Co Inc 1019 Central Bldg Wichita Kans
Willard Pease Drlg Co Box 1532 Grand Junction Colo
Penrod Drlg Co 1320 Mercantile Securities Bldg Dallas Tex
Perkins Drlg Co Box 1232 Duncan Okla
Perrine & Perrine Drlg Contr Box 87 Salem Ill
Petrolex Inc 46 Hemway San Francisco Calif
H F Pettigrew Drlg Acct 2838 Republic Natl Bk Bldg Dallas Tex
Pickrell Drlg Co 705 Fourth Natl Bk Bldg Wichita 2 Kans
Pico Drlg Co Box 512 Breckenridge Tex
Pierce Drlg Co 605 Oil & Gas Bldg Wichita Falls Tex
Louis Pitcock Drlg Co Box 749 Graham Tex
C C Pollard Box 65 Ft Stockton Tex
Fred Pool Drlg Co 3106 Lockheed Midland Tex
Pool & Gerlich Drlg Co Box 1940 San Angelo Tex
Powell Drlg Co 412 Union Center Bldg Wichita Kans
Graham Powell Drlg Co 129 N Sycamore St Centralia Ill
The Power Rig Drlg Co Box 1436 OCS Lafayette La
Prairie Drlg Co Inc Box 2068 Casper Wyo
Prime Drlg Co 814-16 Union Center Wichita Kans
Prince Marine Drlg & Expl Co 434 Bk of Southwest Bldg Houston 2 Tex
Producers Drlg Co Inc 927 Natl Bk of Commerce Bldg New Orleans La
Pyburn Drlg Co Box 4276 Shreveport La

R

R-G Drlg Co 403 City Natl Bk Bldg Wichita Falls Tex
R W I T Drlg Co 506 Diamond St Holdenville Okla
Ramey Well Serv Suite 401P Robertson Bldg Wichita Falls Tex
G H Ray Well Serv Box 68 Cement Okla
Rebstock & Reeves Drlg Co 450 Saratoga Bldg New Orleans 12 La
Red River Drlg Co Cook Bldg Breckenridge Tex
Reed Drlg Co Inc 1209 Atlas Bldg Tulsa Okla



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R W Rine Drlg Co 420 Union Center Wichita Kans
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Robinson Drlg Co Box 970 Colorado City Tex
Robinson Drlg Co Box 153 Abilene Tex
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Rocky Mountain Drlg Co 550 S Flower St Los Angeles Calif
Roden & McRae Drlg Co Box 2286 Casper Wyo
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Dwight M Ross Drlg Co 223 Hamilton Bldg Wichita Falls Tex
Don M Rounds Drlg Co Inc 925 Petroleum Club Bldg Denver 2 Colo
Rowan Drlg Co Inc Drawer 12247 Ft Worth 16 Tex
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Ruhl Drlg Co Inc 1621 Bk of Southwest Bldg Houston 2 Tex
Rupp-Ferguson Oil Co 522 Union Center Bldg Wichita Kans
Rutledge Drlg Co Box 2239 Santa Fe N Mex

S

Sabre Drlg Co 222 Hughes Bldg Cushing Okla
St John Drlg Co Box 639 Ballinger Tex
San Juan Drlg Co Box 728 Farmington N M
Santa Fe Drlg Co Box 310 Whittier Calif
Santa Rosa Drlg Co Box 633 Apple Valley Calif
Schafer Drlg Co 2400 Liberty Bk Bldg Oklahoma City Okla
Scooter's Drlg Serv 1215 Sklar Bldg Shreveport La
A L Schlaikjer Box 761 Newcastle Wyo
Schulz & Brannan Drlg Co 621 Staley Bldg Wichita Falls Tex
Seibold Drlg Co 106½ N Harrison Cushing Okla
SeRoBee Drlg Co Inc 521-22 Union Natl Bk Bldg Wichita Kans
Sharp Drlg Co Box 1271 Midland Tex
Sheets & Walton Drlg Co Box 152 Breckenridge Tex
Shelley-Miller Drlg Co 205 Miller Bldg Wichita Kans
Sherin Drlg Co Inc 1709 First Natl Bldg Oklahoma City Okla
Shields Drlg Co Inc Box 709 Russell Kans
Shields Oil Producers Box 709 Russell Kans
Shulman Bros Box 191 Vandalia Ill
Signal Drlg & Expl Inc 203 Mayo Bldg Tulsa Okla
Joe Simpkins 6421 Easton Ave St Louis 14 Mo
Simpson & Harris Drlg Co 2975 Wilshire Blvd Los Angeles 5 Calif
C J Simpson Drlg Co 10353 Denton Drive Dallas 20 Tex
Sitton & Norton Drlg Co 406 Lubbock Natl Bk Bldg Lubbock Tex
Skinner & McDougal Drlg Co Box 8774 Oklahoma City Okla
Smallwood & Son Drlg Co 3657 E Kiest Blvd Dallas Tex
Smiley & Little Drlg Co 1635 SE 29th St Oklahoma City Okla
B B Smith Inc Box 5103 Midland Tex
James Smith Drlg Contr Box 33 Mertzon Tex
Sojourner Drlg Corp Box 679 Abilene Tex
J D Speer Healdton Okla
J D Sprecher Box 299 Casper Wyo
Steen Drlg Co 619 West Bldg Houston Tex
Stice Drlg Co Box 678 Beeville Tex
Stickle Drlg Co 823 S Detroit Tulsa Okla
Straight & Kane Box 919 Bartlesville Okla
Strait Drlg Inc Box 90 Eldorado Kans
Strata Drlg Inc Tenth and Odell Great Bend Kans
C W Strotman Drlg Co 620 S 30th St Mattoon Ill
Summit Drlg Corp 414 Atlas Life Bldg Tulsa 3 Okla
The Sun Drlg Co 2975 Wilshire Blvd Los Angeles 5 Calif
Sunnyland Contracting Co Inc Box 388 Rayne La
Sutton Prod Co Box 6446 San Antonio Tex
Symons Drlg Co 999 Houston Club Bldg Houston 2 Tex

T

Target Drlg Corp 421 Mayo Bldg Tulsa Okla
Temple Drlg Co Inc 320 Indiana Bk Bldg Evansville Ind
Tennant Drlg Co 1220 N Denver Tulsa Okla
Texas Drlg Co Box 183 Monahans Tex
Texas R F O Inc 421 Meadows Bldg Dallas 6 Tex
Tex-Mex Drlg 1211 Fidelity Union Life Bldg Dallas 1 Tex
Thomas & Billups Drlg 809 Citizens Natl Bk Bldg Abilene Tex
A W Thompson Inc Box 2524 Houston 1 Tex
Thompson & Wathan Drlg Co R R No 1 Flora Ill
Thrasher Drlg Co Inc 1602 Beck Bldg Shreveport La
Tibbits Drlg Co 1000 Oil and Gas Bldg Wichita Falls Tex
Timberland Expl Co 1069 San Jacinto Bldg Houston 2 Tex
Tolson Drlg Co 213 Triangle Bldg Pawhuska Okla
Trachta Drlg Co Box 67 Muenster Tex
Transit Corp 1516 Liberty Bk Bldg Oklahoma City Okla
Trant Drlg Co 1201 Peoples Bk Bldg Tyler Tex
Trio Drlg Co 3013 Nussbaumer Dallas 26 Tex
Triple S Drlg Co Rt 1 Box 393 Broken Arrow Okla
Tri-Service Drlg Co Box 1785 Midland Tex
Troop Drlg Co Box 145 St Elmo Ill
Troup & Suttles Inc 506 Diamond Holdenville Okla
Tucker Drlg Co Box 1876 San Angelo Tex

U

Rip C Underwood 553 First Natl Bk Bldg Amarillo Tex
United Drlg Co 8750 Holloway Dr Los Angeles 46 Calif

V

V S & S Drlg Co 1004 Ridgley Bldg Springfield Ill
V-T Drlg Co 711 Hulman Bldg Evansville Ind
Viersen & Cochran Box 280 Okmulgee Okla
Viking Drlg Co 102 W Crockett St San Antonio 5 Tex

W

W L B Drlg Co 6635 Chocolate Bayou Rd Houston 21 Tex
Wade Drlg Co Inc 413 Wright Bldg Tulsa Okla
Wagner & Wyant Drlg Co Inc 414 Petroleum Bldg Amarillo Tex
Earl F Wakefield 515 Union Center Bldg Wichita Kans
Walters Drlg Co Inc 4114 McMillan Dallas 6 Tex
Rusty Walters Drlg Co Box 304 Bakersfield Calif
Ward Drlg Co 106 Oil & Gas Bldg Wichita Falls Tex
Tommy Ward Drlg Co 524½ N Kansas Liberal Kans
Travis Ward Drlg Co Box 711 Athens Tex
Warren Drlg Co 1012 Mayo Bldg Tulsa 3 Okla
Warton Drlg Co Box 2807 Odessa Tex
Carnes W Weaver Drlg Co 326 Gulf Bldg Houston Tex
C B Webster Drlg Co 609 San Jacinto Bldg Houston 2 Tex
Dick Wegener Drlg Co 1820 First Natl Bldg Oklahoma City Okla
Well Drillers Inc 2001 First City Natl Bk Bldg Houston 2 Tex
Wells Drlg Co 5382 Cherry Ave Long Beach 5 Calif
Wes-Tex Drlg Co Box 2058 Abilene Tex
Art West Drlg Co 205 O'Michael Bldg Odessa Tex
West Central Drlg Co 717 Citizens Bk Bldg Abilene Tex
Western Drlg Co Inc 902 Lubbock Natl Bk Bldg Lubbock Tex
Western Serv Drlg Co Inc Box 1428 Odessa Tex
Chester H Westfall Drlg Co 1612 First Natl Bldg Tulsa Okla
Westlund Drlg Co Box 197 Midland Tex
Carl J Westlund Inc Box 197 Midland Tex
Fred Wilson Drlg Co 1604 Beck Bldg Shreveport La
W W Wise Drlg Inc Box 297 Tyler Tex
Wheless Drlg Co Box 368 Shreveport La
Wilbanks & Rutter Drlg Co 2200 Scurry St Big Spring Tex
A W Williams Drlg Co Inc 411 Virginia St Mobile Ala
Williams Drlg Co Inc Box 851 Springhill La
Walter W Willis 813 Broadway Mt Vernon Ill
Wilson Drlg Co Box 933 Jackson Miss
C R Winn Drlg Contr Box 331 Salem Ill
Wolfe Drlg Co Box 559 Tulsa Okla
Woodson Prod Co 412 Exposition Dallas 26 Tex
Woolf & Magee Inc Box 635 Tyler Tex

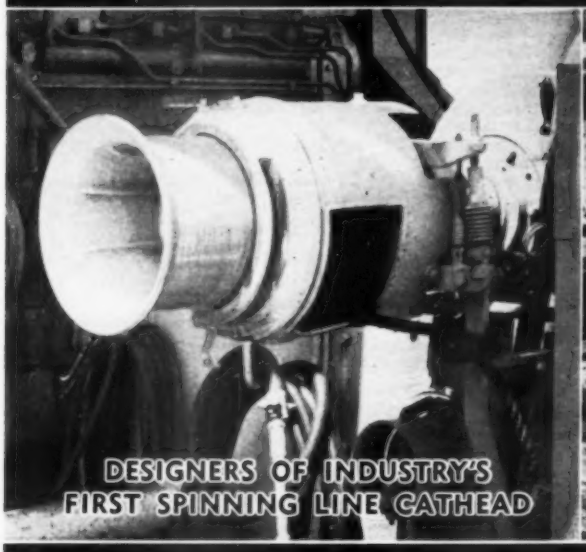
Y

S P Yates Drlg Co 311 Carper Bldg Artesia N Mex
Marshall R Young Drlg Co Drawer 712 Brookhaven Miss
Wesley C Young Drlg Co Box 5733 Sonora Tex

U. S. Contract ROTARY Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALABAMA						
Mobile County						
Zach Brooks Drlg Co	3	dsl	900	Brwstr N-7	900	8,500
	4	gas	1350	Brwstr N-75	1350	12,000
Drlg & Expl Co of Delaware Inc	23	gas-gaso	1000	Natl 100	900	12,000
Jett Drlg Co Inc	104	dsl	1250	Brwstr N-75	1000	12,000
	108	dsl	1250	Brwstr N-75	1000	12,000
	109	gas-gaso	1000	Brwstr N-7	800	9,500
Sunnyland Contr Co Inc	11	dsl	—	Ideco H-750	520	11,000
	14	dsl	1800	Beth Tornado	1200	16,000
ALASKA						
Kenai Peninsula						
Coastal Drlg Co	3	dsl	1000	Emsco A-800	1650	13,000
	5	dsl	1950	Emsco GB-800	1300	14,000
ARIZONA						
Apache County						
D-K Drlg Co	1	gas	675	Natl 50	675	7,500
ARKANSAS						
Franklin County						
Wolfe Drlg Co	3	gas-btne	536	Natl 50	536	7,500
Johnson County						
Falcon Seaboard Drlg Co	16	gas-btne	425	M-CSCO U-15	425	8,500
Hempstead County						
Glenn Drlg Co	1	dsl	200	M-CSCO U-10	300	5,000
Lafayette County						
McCalman Drlg Co Inc	1	dsl	—	Brwstr N-4	300	5,500
Miller County						
Crow Drlg & Prod Co	5	dsl	825	Brwstr N-7	825	9,000
Milton Crow Inc	6	dsl	260	Brwstr N-4	260	5,500
Nevada County						
Montgomery Drlg Co	2	gas-btne	415	Brwstr N-55	—	7,500
Saline County						
Walters Drlg Co Inc	4	gas	130	Mayhew 1000	130	600/2⅛"
	8	gas	220	Mayhew 1000	220	600/2⅛"
Union County						
F E Hargraves & Sons Drlg Co	3	btne	185	Brwstr W-50	185	2,800/3½"
L & N Drlg Co	1	btne	260	Brwstr N-3	185	3,500
CALIFORNIA						
Colusa County						
B J & M Drlg Co Ltd	1	dsl	600	M-CSCO U-35D	400	7,000
Brown Drlg Co	9	gas	900	Natl 50-CA	450	8,500
Fresno County						
Camay Drlg Co	2	gas	1080	Wlsn Titan	1000	12,000
Glenn County						
B J & M Drlg Co Ltd	2	gas	450	Emsco GA-500	450	7,500
Brown Drlg Co	2	dsl	825	"Oilwell" 66	550	9,500
	3	dsl	825	"Oilwell" 66	550	9,500
	7 "Mgty Mole"	dsl	900	Emsco GC-300	600	9,500
Kern County						
B J & M Drlg Co Ltd	3	gas	450	Natl 50	775	8,500
	4	dsl	600	Natl 50	600	8,500
Barnes Core Drlg Co	D-10	dsl	450	Custom	450	5,500/3½"
	D-11	dsl	225	Custom	225	3,000/3½"
Camay Drlg Co	1	gas	1075	Emsco J-1000	1000	12,000
	8	dsl	850	Emsco A-800	1200	12,000
Coastal Drlg Co	1	dsl	3000	Emsco J-1250	1920	16,000
	2	dsl	800	Emsco J-750	1320	11,000
	4	gas	1000	Emsco GB-800	1050	12,000
Drlg & Prod Co	2	dsl-gas-gaso	400	Crdwll O	432	6,000
Enterprise Oil Co	3	dsl	300	Wlsn Torcair	150	4,000/3"
	4	dsl-LPG	300	Howard-Turner	220	2,800
Armstrong Fowler Inc	2	dsl	300	Natl T-12	250	3,000
John S Hagestad Drlg Co	1	dsl	570	Emsco GB-350	400	7,000
	4	dsl	680	Ideco H-525	440	7,500
Clyde Hall Drlg Co Inc	5	gas-btne	1000	Emsco GB-800	1000	12,000
Haney & Williams Drlg Co	3	gas	1250	Natl 75	1350	10,000
	5	gas	1750	Wlsn Titan	1050	13,000

KELCO PIONEER IN SAFETY DRILLING EQUIPMENT



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AIR OPERATED POWER SLIPS • TUBING TONGS

KELCO BEN F. KELLEY CO., Inc.
TULSA, OKLAHOMA

SALES AND SERVICE REPRESENTATIVES IN MAJOR DOMESTIC OIL CENTERS FOR EXPORT, CONTACT IDECO—ONE OF THE DRESSER INDUSTRIES OR YOUR FAVORITE SUPPLY COMPANY

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Ivy Drlg Co	1	dsl	185	Hopper IG	185	1,500
	2	btne	185	Hopper GF	185	3,000
Fred Johnson Drlg Co	2	gas-gaso	1750	Emsco J-1000	1050	10,000
K L Kellogg & Sons	18	gas	925	Natl 50	650	7,000
	19	dsl	1200	Natl 75	790	9,500
	25	dsl	1480	Natl 75	1480	9,500
	27	gas	2000	Natl 100	1050	13,000
	28	dsl	1350	Natl 100	1100	13,000
	32	gas	1400	Natl 75	1050	9,500
Knight Drlg Co	1	dsl	1020	M-CSCO U-35D	500	8,000
	2	dsl	1020	Natl 50-CA	720	9,500
Newton Drlg Co	4-40	dsl	620	Emsco GB-250	320	6,000
Rocky Mountain Drlg Co	10	dsl	1850	Emsco J-1000	1850	15,000
	13	gas	1550	Emsco J-1250	1550	20,000
	14	gas	1500	Emsco J-1250	1500	20,000
Kings County						
Newton Drlg Co	2	dsl	500	Ideco H-40	320	5,000
Los Angeles County						
Camay Drlg Co	3	gas	855	Natl 75	650	9,000
	4	gas	555	Emsco 500	500	7,500
	5	gas	535	Natl 50	500	7,000
	6	gas	605	Natl 50	500	7,000
Drlg & Expl Co of Delaware Inc	20	gas-gaso	1200	Natl 110	900	13,500
	31	gas-gaso	1500	Natl 130	1200	18,000
Drlg & Prod Co	1	dsl	400	Crdwll	350	6,000
F E Gober Drlg Co	2	gas	900	Natl 50-A	450	7,500
Al Godfrey Drlg Co	1	LPG	160	—	160	2,500
John S Hagestad Drlg Co	2	dsl	540	Ideco H30-D	340	4,500
Haney & Williams Drlg Co	1	dsl	450	Wlsn Gnt Trcr	300	5,500
	6	elec	850	Natl 75	500	10,000
Fred Johnson Drlg Co	1	gas-gaso	1050	Emsco J-1000	1050	12,000
	4	elec	600	Natl 50	600	800
K L Kellogg & Sons	23	gas	2090	Natl 75	790	9,500
	34	gas	2475	Natl 125	2475	16,000
Knight Drlg Co	3	gas	1450	Beth M-58	750	11,000
Macrate Prod Co	2	dsl	300	Ideco HD-30	190	3,500
	7	gas	300	Wgnr Mrhse	250	4,000
Lottie B McFann Drlg Co	1	gas-btne	550	Natl 50	450	7,000
Rocket Drlg Co	1	gas-btne-prop	555	Emsco G-300	350	4,500
Rocky Mountain Drlg Co	7	gas	1200	Natl 100	1110	15,000
Santa Fe Drlg Co	25	gas	1200	Natl 55	900	10,000
	29	elec	1000	Natl 3410-½FE	800	15,000
Simpson & Harris Drlg Co	2	gas	432	Beth	450	7,500
The Sun Drlg Co	1	dsl	950	Natl 110	1425	15,000
	2	gas	1400	Natl 125	1250	15,000
	3	elec	750	Natl 110	1100	15,000
	4	elec	1000	Natl 110	1100	15,000
	5	gas	1850	Natl 110	1500	15,000
Sutton Drlg Co	3	dsl	300	Brwstr N-4	350	6,500
	4	dsl	350	Brwstr N-4	875	6,500
Monterey County						
Newton Drlg Co	1	dsl	300	Ideco H-30	300	4 000
Orange County						
Santa Fe Drlg Co	28	gas	1200	Natl 80-B	1350	12,000
San Benito County						
Petrolex Inc	1	dsl	225	Hopper Blitz	185	5,000/3½"
San Bernardino County						
Santa Rosa Drlg Co	1	prop-gas	155	—	130	2,000
San Joaquin County						
Santa Fe Drlg Co	32	dsl	450	Ideco H-40	300	6,000
Rusty Walters Drlg Co	1	dsl	300	Cooper D-50	300	6,500/4"
Solano County						
Rusty Walters Drlg Co	1	dsl	300	Wlsn Mogul	300	7,000/4"
Stanislaus County						
Santa Fe Drlg Co	3	gas	900	Emsco G-500	440	7,500
Ventura County						
Camay Drlg Co	9	gas	1900	Natl 130	1900	16,000
Drlg & Expl Co of Delaware Inc	28	gas-gaso	800	Natl 50-A	750	10,000
	29	gas-gaso	1500	Natl 34-10	1200	18,000
John S Hagestad Drlg Co	3	dsl	625	Emsco GB-350	400	7,000
Haney & Williams Drlg Co	2	gas	1050	Natl 50	700	8,000
K L Kellogg & Sons	7	gas	2240	Natl 100	1050	13,000
	29	gas	1370	Natl 75	700	9,500
	31	gas	1580	Natl 125	1050	16,000
	36	gas	2475	Natl 125	2475	16,000
Rocky Mountain Drlg Co	1	gas	1200	Natl 75	900	11,000
	2	gas	1200	Natl 75	900	11,000
	3	gas	1200	Natl 100	900	14,000
	4	gas-dsl	1550	"Oilwell" 96	1850	20,000
	5	gas	1850	"Oilwell" 96	1850	20,000
	6	gas	1550	Emsco J-1000	1550	15,000
	8	gas	1400	Natl 125	1750	20,000
	9	gas	1500	Natl 125	1500	20,000
	12	gas	1850	Natl 125	1850	20,000
	15	gas	1200	Emsco J-750	900	11,000
Sante Fe Drlg Co	9	gas	1050	Wlsn Titan	900	10,000
	26	gas	1200	Wlsn Titan	900	10,000
Simpson & Harris Drlg Co	1	gas	464	Natl 50	432	7,000
United Drlg Co	1	gas	450	Emsco EDA	450	6,000
COLORADO						
Western Drlg Co Inc	9	btne	500	—	500	5,000
Archuleta County						
Rutledge Drlg Co	7	gas-btne	375	M-CSCO U-15	600	8,000
Denver County						
Brinkerhoff Drlg Co Ltd	2	dsl	370	Natl 50-A	600	8,000
Dolores County						
Foree Drlg Co	2	gas-btne	300	M-CSCO U-15	600	7,500
Jackson County						
Herndon Drlg Co	8	gas	600	Natl 50-A	750	10,500
La Plata County						
Anschutz Oil Co Inc	4	gas	800	Wlsn Giant	700	8,500
Exploration Drlg Co	10	gas	525	M-CSCO U-15	400	8,000
Moran Bros Inc	8	gas	900	Wlsn Gnt	750	9,500
Las Animas County						
Earl F Wakefield	2	dsl	640	Wlsn Gnt Rdair	640	8,500
Logan County						
Exeter Drlg Co	4	dsl	400	Natl T-32	300	6,000
Exploration Drlg Co	1	gas	470	Beth S-60	500	8,000
Herndon Drlg Co	3	gas	600	Natl 50	750	8,000
Lewis Bros Inc	1	dsl	376	Crdwll J-450	476	7,500
Mesa County						
Nye & Snell Drlg Co	4	dsl	320	M-CSCO U-15	320	6,000
Moffat County						
Camay Drlg Co Rocky Mt Div	5	gas	680	Natl 50-A	450	8,000
Carmack Drlg Co	5	gas	400	Natl T-32	320	6,000
Nye & Snell Drlg Co	1	gas	550	"Oilwell" 66	550	6,000
Montezuma County						
Exploration Drlg Co	16	gas	725	Natl 75	600	9,000
Montrose County						
Mountain States Drlg Co Inc	15	gas-dsl	1400	Natl 125	—	15,000
Morgan County						
B F Allison Drlg Co	1	gas-btne	450	Natl T-32	400	5,500
Ashby Drlg Co Ltd	1	dsl	300	Natl T-20	300	8,000/3½"
	2	dsl	300	Natl T-20	300	8,000/3½"
Exeter Drlg Co	2	btne	320	Emsco GA-250	250	6,000/4"
Garvey Drlg Co	12	dsl	300	Wlsn Giant	320	6,000/3½"
	17	dsl	300	Wlsn Rdair	450	7,000/3½"
Lewis Bros Inc	2	btne	360	M-CSCO U-15	460	6,500
Prowers County						
R W Rine Drlg Co	1	gas-btne	620	M-CSCO U-15	600	7,500
Rio Blanco County						
Carpenter-Trant Drlg Co	1	btne	185	Crdwll RL	185	3,000
San Miguel County						
Mountain States Drlg Co Inc	11	gas-dsl	1000	Natl 80-B	—	12,500
Washington County						
B F Allison Drlg Co	5	gas-btne	450	Frnks 137	390	5,500
Weld County						
B F Allison Drlg Co	2	gas-btne	675	M-CSCO U-15	675	8,500
Lohmann-Johnson Drlg Co Inc	1	dsl	300	Natl 50	480	5,500
FLORIDA						
Gadsden County						
A W Williams Drlg Co Inc	1	dsl	186	Joy 300	200	6,000/2⅞" 4,500/4"
ILLINOIS						
Joe Simpkins	1	dsl	—	Emsco GA-160-T	500	3,500
	3	dsl	350	Frnks 4000	350	4,000
	4	dsl	350	Spencer	350	2,500
Bond County						
W L Dillier	2	gas	—	Failing 2500	130	2,000
Thompson & Wathan Drlg Co	1	btne	300	Natl T-20	185	4,500
Christian County						
V S & S Drlg Co	2	dsl	—	Wlsn	—	2,400
Clay County						
Claypool Drlg Co	2	btne	300	Natl T-12	185	4,500
J W Rudy	1	dsl	150	Natl T-20	185	5,000
	50	dsl	250	Natl 50	214	6,000
Shulman Bros	1	dsl	330	Crdwll S-350	—	5,500
V S & S Drlg Co	5	gas	—	Crdwll	—	4,000
C R Winn Drlg Contr	1	dsl	135	Wlsn Super	135	2,800/3½"
Clinton County						
M Mazzarino	—	gas-gaso	200	Frnks 2000	200	2,500
Perrine & Perrine Drlg Contr	1	btne	—	Crdwll S	185	6,000
Crawford County						
W L Dillier	4	gas	—	Failing 2500	130	2,000

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MILWHITE

MUD SALES COMPANY

HOUSTON, TEXAS

DIVISION OF MISSISSIPPI RIVER FUEL CORPORATION

MUD SERVICE
BY MILWHITE
Pays!

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Effingham County						
Ted Lindsay	3	dsl	160	Ideco H-30	160	4,000
Lohmann-Johnson Drlg Co Inc	7	dsl	300	Crdwll S	440	4,500
Franklin County						
C E Brehn	1	dsl	240	Brwstr N-45	—	7,000
Gallatin County						
Calvert Drlg Inc	12	dsl	260	Ideco H-30	260	4,500
Central Drlg Co Inc (Fairfield Ill)	4	dsl	260	M-CSCO U-34	200	4,000-4"
V S & S Drlg Co	4	dsl	—	Beth	—	4,200
	6	gas	—	Cooper Spdr	—	3,000
Hamilton County						
Calvert Drlg Inc	11	dsl	260	Natl T-32	190	5,000
	16	dsl	260	Ideco H-35	190	5,000
Jefferson County						
Herndon Drlg Co	7	gas	409	Natl T-32	559	5,000
Ted Lindsay	2	dsl	220	Natl T-16	220	5,000
C R Winn Drlg Contr	2	dsl	225	Crdwll L	225	4,000-3½"
Kankakee County						
Moran Bros Inc	14	dsl	350	Natl T-12	350	4,500
Lawrence County						
Central Drlg Co		gas	185	Wlsn Mogul	135	3,000-3½"
W L Dillier	1	dsl	—	Natl T-12	212	3,000
Gene Miller Inc	5	dsl	300	Brwstr N-4	—	4,500
Marion County						
Ted Lindsay	1	dsl	220	Crdwll S	160	4,500
Graham Powell	1	dsl	—	Natl 50	—	6,000
Troop Drlg Co	1	gas-gaso	—	Natl T-20	200	4,500
Pike County						
W L Dillier	3	gas	—	Failing 2500	130	2,000
Richland County						
Herndon Drlg Co	5	gas	375	Brwstr N-4	375	4,500
Saline County						
Eakle & Holder Drlg Co	1	dsl	300	Brwstr N-4	200	5,500
Henry Gwaltney Drlg Co	3	gas	100		100	1,500
Wabash County						
The Noah Petroleum Co	1	dsl	300	Brwstr N-4	300	5,500
Washington County						
Graham Powell	2	dsl	—	Natl T-12	—	3,200
Wayne County						
Calvert Drlg Inc	8	dsl	260	Ideco H-30	190	4,500
Central Drlg Co Inc (Fairfield Ill)	6	gas	260	Natl 40	200	4,500-3½"
D B Lesh Drlg Co	4	gas	450	Natl 50	450	7,000
White County						
General Geophysical Co	27	dsl	—		400	4,500
Harris Drlg Co	2	btne	276	Natl 40	172	4,000
	3	dsl	285	Natl 50	285	8,500
INDIANA						
Gibson County						
Eakle & Holder Drlg Co	2	dsl	400	Emsco G-300	400	5,500
Henry Gwaltney Drlg Co	1	dsl	200	Natl T-12	165	3,000
Harris Drlg Co	1	btne	195	Crdwll S	172	4,000
Highland Oil	2	—	—	B Erie 28-L	—	2,000
Temple Drlg Co Inc	2	dsl	330	Crdwll S	440	4,500
Posey County						
Herndon Drlg Co	9	gas	240	Natl T-25	390	4,000
Houchins Drlg Co	1	dsl	300	Natl T-20	300	4,500
Lohmann-Johnson Drlg Co Inc	6	btne	300	Crdwll S	440	4,500
Vanderburgh County						
Kendall-Davis Drlg Co Inc	2	dsl	300	Crdwll S	300	4,000
IOWA						
Dallas County						
Kirby Oil Ind	—	dsl	400	Brwstr N-4	400	4,500
	—	gas-gaso	400	Mayhew 3000	145	3,000
	—	dsl	300	M-CSCO U-34	275	4,500
KANSAS						
Barber County						
Beardmore Drlg Co	1	dsl	300	Natl 50	450	6,000
Garvey Drlg Co	5	dsl	175	M-CSCO U-15	296	5,000
Murfin Drlg Co	3	dsl	260	Natl T-20	260	5,000
Patton Drlg Co Inc	1	gas	—	Natl 50	450	6,500
	2	dsl	—	Natl 50	350	5,500
Pickrell Drlg Co	10	dsl	270	Ideco	300	6,500
Stickle Drlg Co	6	dsl	300	Brwstr N-45	300	6,500
Strata Drlg Inc	1	dsl	520	M-CSCO U-15	520	8,500
Barton County						
Ari-Kan Drlg Co	1	dsl	165	Natl T-12	150	4,500
Iron Drlg Co	7	dsl	268	Emsco GB-160	236	4,500
Isern Drlg Co	1	dsl	450	M-CSCO U-15	450	7,000
Mallonee Drlg Co Inc	1	btne	220	Beth Breeze	200	4,500
Shelley-Miller Drlg Co	1	dsl	379	Wlsn Gnt	300	4,860
Cowley County						
Peak Drlg Co Inc	12	gas-LPG	220	Natl T-12	220	4,000
	14	gas-LPG	200	Brwstr N-35	200	4,000
Crawford County						
Walters Drlg Co Inc	3	gas	130	Mayhew	130	1,000
Edwards County						
Gabbert-Jones Drlg Co	1	gas	380	Emsco 300	380	5,000
Herndon Drlg Co	6	gas	409	Natl T-32	559	6,000
Lohmann-Johnson Drlg Co Inc	3	btne	300	Natl 50	450	5,500
Stickle Drlg Co	4	dsl	300	Ideco H-35	300	5,000
Ellis County						
Garvey Drlg Co	11	dsl	175	Wlsn Giant	296	5,000
K & E Drlg Inc	2	dsl	285	Natl T-20	—	5,000
Murfin Drlg Co	2	dsl	200	Natl T-20	260	5,000
Transit Corp	4	dsl	280	Emsco	212	4,500
Ellsworth County						
Garvey Drlg Co	10	dsl	175	Wlsn Gnt	296	5,000
Finney County						
Garvey Drlg Co	14	dsl	175	Wlsn Gnt	296	5,000
General Drlg Co	5	—	—	M-CSCO U-15	—	9,000
Helmerich & Payne Inc	26	gas	500	Emsco GB-500	700	9,000
Graham County						
Empire Drlg Co (Kans)	1	dsl	300	Natl T-32	300	5,000
Garvey Drlg Co	9	dsl	175	Wlsn Gnt	296	5,000
Herndon Drlg Co	10	gas	409	"Oilwell" 64-A	559	4,500
Stickle Drlg Co	5	dsl	300	Natl T-32	300	5,500
Haskell County						
Garvey Drlg Co	22	dsl	300	Wlsn Mogul 42	450	7,000
R W Rine Drlg Co	5	gas-btne	520	Brwstr N-55	550	8,500
Earl F Wakefield	3	dsl	440	Wlsn Gnt Rdair	440	6,000
Kingman County						
D & M Drlg Co Inc	2	gas-btne	600	M-CSCO U-15	600	9,000
Gabbert-Jones Drlg Co	3	gas	380	Emsco 300	380	5,000
Pickrell Drlg Co	1	dsl	450	M-CSCO U-15	450	6,500
Powell Drlg Co	1	dsl	—	Emsco GB-350	350	6,500
Kiowa County						
Rupp-Ferguson Oil Co	1	dsl	350	Ideco H-35	350	5,000
Meade County						
D & M Drlg Co Inc	3	dsl	600	M-CSCO U-15	600	7,500
Garvey Drlg Co	18	dsl	300	W'sn Rdair	450	6,000
Moran Bros Inc	11	dsl	300	Wlsn Gnt	450	6,000
McPherson County						
Donald T Ingling	4	dsl	225	Brwstr N-4	225	5,500
Morton County						
Graham-Michaelis Drlg Co	8	dsl	400	Crdwll D	400	5,000
Holm Drlg Co	5	dsl	300	"Oilwell" 52-T	300	5,500
Nye & Snell Drlg Co	2	dsl	320	Wlsn M-46	320	5,000
Pawnee County						
Iron Drlg Co	6	dsl	240	Emsco GA-250	268	5,000
Pratt County						
Gabbert-Jones Drlg Co	2	gas	450	Emsco 350	450	7,000
Prime Drlg Co	2	dsl	300	Beth S-45	300	5,000
Rex & Morris Drlg Co	1	dsl	260	Natl T-25	260	4,000
Reno County						
Graham-Michaelis Drlg Co	6	dsl	275	Beth Breeze	175	4,000
Rice County						
Buick Drlg Inc	2	dsl	250	Wlsn Gnt	325	5,000
Rooks County						
Reserve Drlg Co Inc (Kans)	3	dsl	320	Natl T-32	320	5,500
Transit Corp	2	dsl	280	Emsco	—	4,500
	3	dsl	280	Emsco	—	4,500
Russell County						
Mast Drlg Inc	2	dsl	185	Natl T-32	250	5,500
Shields Drlg Co Inc	2	dsl	300	Beth C-50	300	8,000
	3	dsl	300	Wlsn Giant	400	6,000
Sedgewick County						
Garvey Drlg Co	3	dsl	175	M-CSCO U-15	296	5,000
Seward County						
Graham-Michaelis Drlg Co	4	dsl	500	M-CSCO U-15	500	7,000
Lynn Drlg Co	1	gas-btne	300	Natl 50	600	7,000
Musgrove Petroleum Corp	2	dsl	495	Emsco 350	—	7,000
Schafer Drlg Co	9	gas-gaso	300	Ideco H-35	300	7,500
Stafford County						
Garvey Drlg Co	8	dsl	175	Wlsn Gnt	296	5,000
K & E Drlg Inc	1	dsl	295	"Oilwell" T-52	—	6,000
Stanton County						
Holm Drlg Co	4	dsl	560	Wlsn Gnt	300	5,500

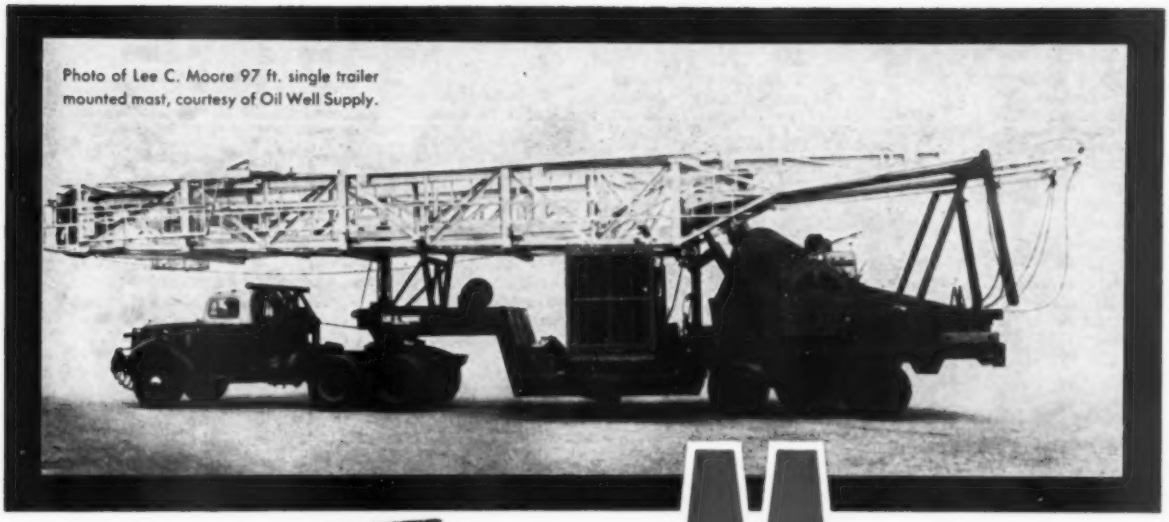

Photo of Lee C. Moore 97 ft. single trailer mounted mast, courtesy of Oil Well Supply.

LEE C.

Moore

TRAILER MOUNTED MASTS

FAST SIMPLE RUGGED

LEE C. MOORE Trailer Mounted Masts are designed for maximum mobility and efficiency.
Well loads are inside the mast structure, thus eliminating guy lines.
Furnished either with a substructure or with simple bearing beam and screw jacks.
Designed to accommodate a variety of drawworks and power combinations.
Extended in horizontal position — FOR SAFETY.
Legs in true alignment when mast is extended — NO OVERLAP.
Traveling blocks are carried in the mast with lines strung.

SINGLE TRAILER MOUNTED MASTS
86 ft./94 ft./97 ft. /100 ft./126 ft. Export Model

DUAL TRAILER MOUNTED MASTS
97 ft./100 ft./126 ft./126 ft. Export Model

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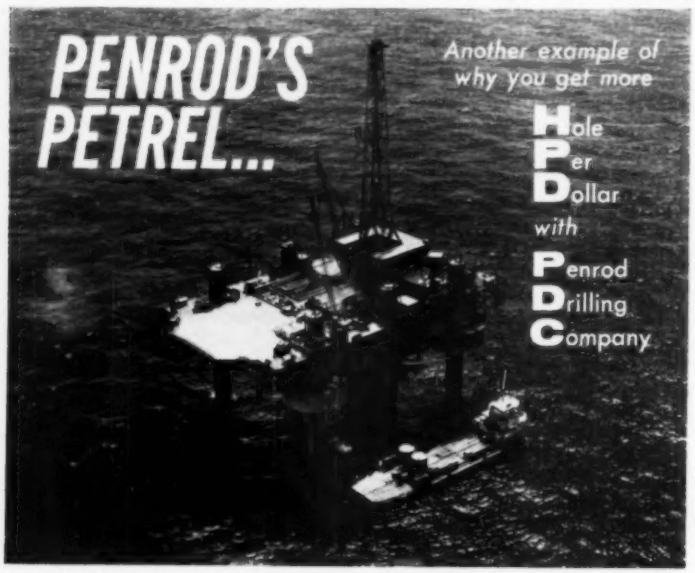
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Stevens County						
Tommy Ward Drlg Co	2	gas	300	Brwstr N-45	600	7,500
Sumner County						
Beardmore Drlg Co	2	dsl	300	Emsco 300	320	4,000
Falcon Seaboard Drlg Co	27	gas-btne	185	M-CSCO U-15	210	5,000
Garvey Drlg Co	15	dsl	175	Wlsn Gnt	296	5,000
Herndon Drlg Co	1	gas	409	"Oilwell" 64-B	559	6,000
Musgrove Petroleum Corp	8	dsl	230	Natl 50	—	5,000
Earl F Wakefield	1	dsl	440	Wlsn Mogul Rdair	440	5,000
Thomas County						
Falcon Seaboard Drlg Co	20	gas-btne	425	M-CSCO U-15	425	8,500
Trego County						
Murfin Drlg Co	4	dsl	260	Wlsn Rdair	450	7,000
Prime Drlg Co	3	dsl	275	M-CSCO U-34	285	4,500
White County						
Walter W Willis	1	dsl	—	Beth S-45E	—	4,500
Wilson County						
Smiley & Little Drlg Co	4	gas	100	Wlsn	100	2,600
KENTUCKY						
Christian County						
Overby Drlg Co Inc	2	dsl-btne	250	Mayhew 2000	—	2,500
Daviess County						
Henry Gwaltney Drlg Co	2	gas-prop	200	Crdwll	165	3,000
Hupp & Hume	2	dsl	300	Natl 40	300	3,000
V-T Drlg Co	1	dsl	220	Crdwll H	160	4,000
Henderson County						
Big Seven Drlg Co	1	dsl	300	Emsco GB	300	4,500
Shulman Bros	2	dsl	330	Crdwll L	—	3,500
Martin County						
Moran Bros Inc	1	gas	1000	"Oilwell" 760	1200	14,000
McLean County						
Hupp & Hume	1	dsl	325	Natl 40	350	4,500
Union County						
Kendall-Davis Drlg Co Inc	1	dsl	300	Wlsn Mogul	300	4,000
Webster County						
Eakle & Holder Drlg Co	3	dsl	300	Ideco H-30	300	5,500
LOUISIANA						
Acadia Parish						
Clegg & Hunt	6	stm	—	Natl 9-DBM	—	14,000
Continental Marine Expl Co	4	gas-btne	2000	Wlsn Titan	1200	14,000
Delta Drlg Co	38	stm	530	Natl 239-S	1135	12,000
Dillard-Waltermire Inc	4	stm	1200	Natl 34-10FE	1500	16,000
Drlg & Expl Co of Delaware Inc	36	stm	1400	Natl 34-8	—	15,000
Falcon Seaboard Drlg Co	1	stm	1200	Ideco Bg Gnt	2000+	20,000
Owen Drlg Co	3	gas	900	Ideco M-1000	—	12,500
	6	gas	600	Natl 75	600	12,000
Steen Drlg Co	2	stm	600	Emsco ECA	—	16,000
Sunnyland Contr Co Inc	8	gas-gaso	—	Crdwll D	312	8,000
Carnes W Weaver Drlg Co	2	gas-btne	900	Ideco	—	11,000
Fred Wilson Drlg Co	9	gas	1200	Natl 80-B	800	12,500
Allen Parish						
Circle Drlg Co Inc	2	gas-btne	800	Brwstr N-75	900	11,000
Penrod Drlg Co	23	dsl	795	Brwstr N-7	700	10,000
Sunnyland Contr Co Inc	7	dsl	—	Ideco H-40	480	8,000
Ascension Parish						
Crawford Drlg Co	1	dsl	695	Brwstr N-7	500	9,000
Delta Drlg Co	11	stm	1000	Emsco UBLS-54	1690	15,000
Nicklos Drlg Co	12	stm	—	Natl	—	17,000
Fred Wilson Drlg Co	7	gas	1200	Natl 80-B	800	12,500
Assumption Parish						
Brewster-Bartle Drlg Co Inc	14	dsl	—	Natl 125	—	16,000
Delta Drlg Co	31	gas-btne	1020	Emsco J-1000	1260	13,000
Falcon Seaboard Drlg Co	12	stm	1200	Natl 2310-1 2FE	2000+	20,000
Nicklos Drlg Co	15	gas-btne	—	Natl 80	1000	13,000
Beauregard Parish						
Clegg & Hunt	9	btne-gas	—	Natl 50-A	—	9,8000
The Power Rig Drlg Co	3	gas-btne	1000	Emsco A-800	—	13,000
Prince Marine Drlg & Exp Co	3	gas	900	"Oilwell" 66	900	10,500
	4	gas	1600	Emsco J-1100	1400+	15,000
Fred Wilson Drlg Co	10	gas	1050	Natl 55	800	10,500



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PENROD LAND AND SEA DRILLING COMPANY

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS SEE READER SERVICE CARD

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Bienville Parish						
Crow Drlg & Prod Co	19	dsl	325	Brwstr C-5	325	7,000/3½"
McAlester Fuel Co	1	btne-gas	—	Emsco GC-500	820	11,000
Montomery Drlg Co	1	gas-btne	700	Emsco GA-500	600	9,500
Wheless Drlg Co	10	gas-btne	770	Brwstr N-7	800	9,500
Bossier Parish						
Butler-Johnson Inc	2	gas-btne	450	Brwstr N-55	450	8,000
H & S Drlg Co	1	gas-btne	1000	Wlsn Titan	1000	12,000
Ruhl Drlg Co Inc	1	—	475	Brwstr N-7	625	8,500
Tex-Mex Drlg Co	8	stm	—	—	1000+	9,000
Williams Drlg Co Inc	1	dsl	278	Wlsn Mogul	172	4,000
Caddo Parish						
Milton Crow Inc	3	gas	600	Brwstr N-7	450	7,500
Gary Drlg Co	1	btne	90	Hercules WXLC-3	90	1,600
	2	btne	145	Buda	200	2,500
F E Hargraves & Sons Drlg Co	2	btne	185	Brwstr W-50	185	2,800/3½"
	4	dsl	275	Brwstr N-A	300	6,000/3½"
Kendrick Bros	1	btne	185	Brwstr N-4	185	5,000
Lunsford Drlg Co	1	LPG	185	Brwstr N-3	145	4,000
	2	LPG	145	Wlsn Spr	145	2,500
Tex-Mex Drlg Co	11	stm	—	—	1000+	12,000
Calcasieu Parish						
Harry T Bryant Drlg Co Ltd	3	gas-btne	700	TIW 5	600	8,000
Circle Drlg Co Inc	4	gas-btne	800	Brwstr N-75	960	11,000
Delta Drlg Co	16	dsl	1200	Beth MC-950	1400	15,000
	25	gas-btne	1520	Emsco J-1250	1250	15,000
Gulf Drlg Inc	1	gas	375	Frnks SAL-5000	450	5,000
Mac Drlg Co	11	stm	800+	Natl 23-9F-ED	1000+	20,000
Symons Drlg Co	U-15	gas	500	M-CSCO U-15	650	9,500
Cameron Parish						
Clegg & Hunt	8	dsl	—	—	1275	18,000
Comet Drlg Co	1	stm	1200	Ideco Big Gnt	—	16,000
	2	dsl	1000	Natl 75	750	10,000
Delta Drlg Co	14	stm	900	Ideco Big Gnt	1690	15,000
	20	gas-btne	1520	Emsco J-1250	1250	15,000
Falcon Seaboard Drlg Co	3	stm	1000+	Alco BIW 12	1200+	17,000
Win Hawkins Drlg Co	1	stm	—	Alco BIW 14	—	15,000
Penrod Drlg Co	16	gas-btne	1900	Emsco J-1400	1500	18,000
	33	dsl	1765	Brwstr N-12A	1725	18,000
	Bge 40	dsl	1850	Brwstr N-12A	1725	18,000
Rowan Drlg Co Inc	Bge 6	dsl-elec	1200	Emsco ED	2800	18,000
	Bge 14	dsl-elec	1600	Emsco ECA	2325	18,000
C B Webster Drlg Co	2	gas	1300	"Oilwell" 96	1450	18,000
	8	stm	1600	Natl FE-34-10	1200+	15,000
Wheless Drlg Co	Bge 12	gas-btne	1085	Natl 80	1200	12,000
Fred Wilson Drlg Co	12	gas	1300	Natl 110	1200	15,000
Catahoula Parish						
Dorris Ballew Inc	6	dsl	380	M-CSCO U-15	600	7,500
Scooter's Drlg Serv	3	dsl	600	Brwstr N-55	600	6,000
Claiborne Parish						
Milton Crow Inc	4	gas	900	Brwstr N-75	675	10,000
Maritzky & Bibby	1	gas	330	Brwstr	185	5,000
	2	gas	330	Crdwll	145	3,000
Wheless Drlg Co	1	gas-btne	510	Brwstr N-45	450	7,500
Woolf & Magee Inc	5	gas-btne	800	Beth MC-450	800	11,000
Concordia Parish						
Rimrock Tidelands Inc	20	dsl	675	Brwstr N-55	900	10,000
Scooter's Drlg Serv	4	dsl	300	Wlsn Giant	300	4,500
De Soto Parish						
Crow Greyhound Drlg Co Inc	1	dsl	300	Brwstr N-4	280	5,500
Hilburn Industries Inc	2	gas	550	Wlsn	—	10,000
Johnson Drlg & Serv Co	1	dsl	340	Beth-Breeze	200	4,500
Eugene Island Area						
Penrod Drlg Co	Bge 50	dsl	2625	Emsco EDES	1250	20,000
	Bge 52	dsl	2000	Emsco EDES	1200	20,000
Evangeline Parish						
Delta Drlg Co	5	gas-btne	900	Natl 100	800	12,000
	21	gas-btne	800	Natl 75	650	9,500
Rowan Drlg Co Inc	4	gas-btne	900	Natl 75	1149	11,000
Franklin Parish						
Butler Johnson Inc	4	gas	500	Brwstr N-4	350	6,500
Montgomery Drlg Co	3	gas-btne	225	Crdwll S	200	5,000
Iberia Parish						
Clegg & Hunt	4	stm	—	Ideco Big Gnt	—	15,000
Columbia Drlg Co	Bge 1	dsl	800	"Oilwell" 76	750	12,000
Nicklos Drlg Co	14	gas-btne	—	Natl 75	1000	12,000
	20	pwr	2350	Natl 130	2250	18,000
Prince Marine Drlg & Exp Co	1	dsl	1500	"Oilwell" 96	1500	15,000
Rowan Drlg Co Inc	Bge 13	dsl-elec	1700	Emsco FCA	2700	18,000
Wheless Drlg Co	Bge 6	gas-btne	1000	Wlsn Titan	1200	12,000

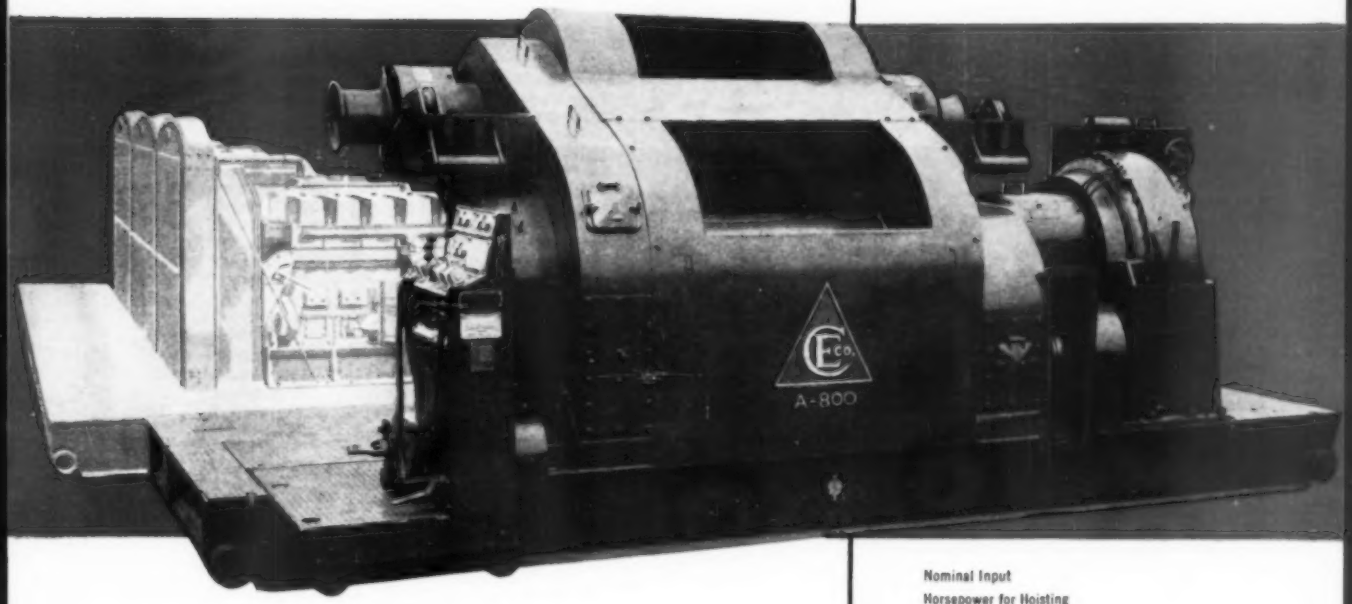
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Iberville Parish						
Circle Drlg Co Inc	7	gas-btne	1500	Ideco 7-11	1200	15,000
A W Eggleston Inc	2	gas-btne	700	Ideco PR-800	700	10,500
M M Lindsey Drlg Co	1	gas	380	Brwstr N-55	—	7,500
Jackson Parish						
Delta Drlg Co	17	gas-btne	1020	Emsco J-1100	1300	15,000
Jefferson Parish						
Brewster-Bartle Drlg Co Inc	9	dsl	—	"Oilwell" 96	1500	16,000
Rowan Drlg Co	Bge 20	dsl	1120	Natl 75	1300	12,000
Jefferson Davis Parish						
Clegg & Hunt	1	stm	—	Emsco 10	—	15,000
Steen Drlg Co	1	stm	750	Emsco ECB	—	17,000
Carnes W Weaver Drlg Co	3	gas-btne	700	"Oilwell"	—	10,500
	7	stm	—	M-CSCO U-117B	—	14,000
C B Webster Drlg Co	3	gas	1250	Emsco J-1250	1300	15,000
	4	stm	1200	Natl FE-34-10	1200+	15,000
Lafayette Parish						
Dillard-Waltermire Inc	8	stm	1200	Natl 34-10FE	1500	16,000
Harry L Edwards Drlg Co	7	stm	1000	Alco BIW 12	1000+	15,000
Nicklos Drlg Co	11	stm	—	Natl	—	17,000
Owen Drlg Co	1	stm	540	Ideco Big Gnt	—	15,000
	4	stm	1000+	Emsco UBLS-54	—	14,000
	7	stm	1000+	Emsco	—	16,000
	9	stm	740	Ideco Big Gnt	540	16,000
Lafourche Parish						
Brewster-Bartle Drlg Co Inc	6	dsl	—	"Oilwell" 96	1500	—
Circle Drlg Co Inc	5	gas-btne	1200	Brwstr N-12	1440	15,000
Crawford Drlg Co	2	stm	—	Emsco ECA	500	15,000
Delta Drlg Co	37	dsl	900	Beth MC-950	1400	15,000
Graney-Hellums Corp	Bge 3	dsl	1775	M-CSCO U-1220	1800	20,000
Kelly Drlg Co Inc	3	pwr	825	"Oilwell" 96	1500	18,000
Norton Drlg Co	Bge 4	dsl	1400	Emsco J-1250	1500	17,000
	Bge 6	dsl	1400	Emsco J-1250	1200	17,000
Penrod Drlg Co	Bge 42	dsl	2000	Brwstr N-12A	1100	18,000
Rowan Drlg Co Inc	Bge 21	dsl-elec	1000	Emsco ECA	1920	12,000
C B Webster Drlg Co	1	dsl	1650	"Oilwell" 96	1800	18,000
	6	stm	1100	Emsco ECA-10½	1200+	15,000
Wheless Drlg Co	Bge 9	dsl	1800	Natl 130	1380	16,000
	Bge 11	gas-btne	1085	Emsco J-1250	1300	13,500
LaSalle Parish						
Penrod Drlg Co	2	gas-btne	570	Brwstr N-45	550	7,000
Leesville Parish						
Kelly Drlg Co Inc	1	stm	600	Ideco Jr Gnt	1200	15,000
Lincoln Parish						
Arrow Drlg Co	16	gas-elec	840	Emsco	—	10,000
Butler-Johnson Inc	1	gas-btne	650	Brwstr N-75	1005	10,000
Delta Drlg Co	8	stm	750	Ideco Supr-Duty	1200	12,000
Johnson Drlg & Serv Co	2	dsl	500	Beth Twister	300	6,500
Penrod Drlg Co	35	stm	—	Emsco UBLS-54	—	13,000
Pyburn Drlg Co	2	gas	250	Wilson	800	9,000
Wheless Drlg Co	2	gas-btne	575	Wlsn Atlas	450	8,500
Madison Parish						
Jett Drlg Co Inc	107	dsl	600	Brwstr N-45	400	7,000
Main Pass Area						
Penrod Drlg Co	Bge 51	dsl	2000	Emsco EDES	1200	20,000
Marsh Island						
Circle Drlg Co Inc	Bge 6	dsl-elec	2300	Ideco ED2500	2750	20,000
Ouachita Parish						
H & S Drlg Co	2	gas-btne	1000	Brwstr N-95	1000	14,000
Wheless Drlg Co	13	gas-btne	640	Emsco J-750	750	10,500
Plaquemines Parish						
Clinch Drlg Co	Bge 1	dsl	—	Emsco GA-350	426	8,500
Continental Shelf Drlg Corp	Belle Claire	dsl	1700	Beth 1013	1950	18,000
Harry L Edwards Drlg Co	Bge 10	dsl	—	Ideco PR-1050	—	16,000
Penrod Drlg Co	Bge 41	dsl	1000	Emsco J-1100	1150	12,000
	Bge 45	dsl	1850	Emsco J-1400	1725	20,000
	Bge 47	dsl-elec	2650	Emsco EDA	1250	20,000
Producers Drlg Co Inc	1	dsl	2000	M-CSCO U-1220	2200	20,000/5"
	2	dsl	2150	M-CSCO U914B	1800	18,000
Rebstock & Reeves Drlg Co	1	dsl	1050	Wlsn Sup Titan	1425	15,000
Rimrock Tidelands Inc	Bge 18	dsl	1000	Emsco GC-500	1500	10,000
Rowan Drlg Co Inc	Bge 18	stm	1800	Emsco ED	750	18,000
Sabine Parish						
Wheless Drlg Co	3	gas-btne	575	Emsco GB-350	450	7,500
St Charles Parish						
Crown Rigs Inc	Bge 2	dsl	2490	Beth 1013	2000	18,000
Delta Drlg Co	32	stm	1200	Ideco Big Gnt	1690	15,000
Win Hawkins Drlg Co	4	stm	—	Natl 3410FE	—	15,000
St John The Baptist Parish						
The Power Rig Drlg Co	4	gas-btne	700	M-CSCO U-15	—	10,000
	8	gas-btne	1500	Ideco 7-11	—	15,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
St Landry Parish						
Mac Drlg Co	3	stm	600	Natl 23-9-FE	1000+	20,000
St Martin Parish						
Harry L Edwards Drlg Co	4	stm	1000	Alco BIW 12	1000	15,000
Gracey-Hellums Corp	Bge 2	stm	1200	Natl 23-9FE	1200	15,000
Wm Hawkins Drlg Co	2	gas-btne	300	M-CSCO U-15	485	9,000
Rowan Drlg Co Inc	30	dsl	1545	Emsco A-1500	1545	20,000
St Mary Parish						
Glegg & Hunt	3	dsl	—	Wisn Titan 56	800	11,500
	Bge 11	dsl-elec	2600	Ideco 2500	1900	23,000
Crown Rigs Inc	Bge 1	dsl	1200	Beth 1013	1200	15,000
Delta Drlg Co	19	stm	1200	Natl 34-10-FE	1690	15,000
Falcon Seaboard Drlg Co	2	stm	1200+	Ideco Bg Gnt	2000+	20,000
Rimrock Tidelands Inc	3	dsl	1450	Brwstr N-12-A	1300	20,000
M M Lindsey Drlg Co	2	gas	290	Natl T-32	—	6,000
Mac Drlg Co	10	gas-btne	1000	Natl 130	1300	20,000
Nickins Drlg Co	18	gas-btne	—	Natl 110	1600	17,000
Norton Drlg Co	Bge 3	stm	1200+	Natl 34-62	1500	17,000
Rimrock Tidelands Inc	15	dsl	2000	Brwstr N-12-A	2000	20,000
C B Webster Drlg Co	5	stm	1350	Natl FE-23-10½	1200+	15,000
	Bge 9	dsl	1850	Emsco J-1400	2200	16,000
Wheless Drlg Co	Bge 14	dsl	1700	Emsco J-1400	1400	16,000
Fred Wilson Drlg Co	8	gas	1600	Natl 110	1200	15,000
	11	gas	1050	Natl 55	800	10,500
South Louisiana						
Gracey-Hellums Corp	4	dsl	1775	Emsco A-1500	1900	20,000
Tensas Parish						
Jett Drlg Co Inc	105	dsl	600	Natl T-32	500	8,000
	112	dsl	1200	Brwstr 55	800	9,000
Terrebonne Parish						
Brewster-Bartle Drlg Co Inc	5	dsl	—	"Oilwell" 96	1500	16,000
	7	dsl	—	"Oilwell" 96	1500	16,000
	8	dsl	—	"Oilwell" 96	1500	16,000
	11	dsl	—	"Oilwell" 96	1500	16,000
	12	dsl	—	"Oilwell" 96	1500	16,000
Continental Marine Expl Co	Bge 3	dsl	750	Natl 110	1000	12,500
Harry L Edwards Drlg Co	12	dsl-elec	1000	Ideco	2000	18,000
Kelly Drlg Co Inc	2	pwr	600	"Oilwell" 96	1500	18,000
Norton Drlg Co	Bge 5	dsl	1200	"Oilwell" 96	1200	17,000
Penrod Drlg Co	Bge 46	dsl-elec	2500	Emsco ECB	1250	20,000
Prince Marine Drlg & Exp Co	2	dsl	1850	"Oilwell" 96	1500	16,000
Rowan Drlg Co Inc	Bge 1	dsl-elec	1600	Emsco ECA	2475	18,000
	Bge 26	dsl	1325	Natl 100	1545	14,000
Wheless Drlg Co	Bge 8	dsl	1880	Natl 130	1455	16,000
	Bge 15	dsl	1975	Natl 130	1455	16,000
Union Parish						
Drlg & Expl Co of Del Inc	32	stm	1400	Emsco ECA	—	15,000
Monroe Drlg Co Inc	1	stm	260	Natl U-2	—	12,000
Vermilion Parish						
Brewster-Bartle Drlg Co Inc	2	dsl	—	"Oilwell" 96	1500	16,000
Circle Drlg Co Inc	3	gas-elec	1200	Ideco Big Gnt	2100	15,000
Delta Drlg Co	35	gas-btne	1200	Emsco J-1100	1200	15,000
Dillard-Waltermire Inc	6	stm	1200	Natl 34-10FE	1560	16,000
Harry L Edwards Drlg Co	6	stm	1000	Natl 23-10½	1000	15,000
A W Eggleston Inc	1	gas-btne	600	Natl 60A	600	9,500
	3	dsl	900	Ideco PR-1050	900	14,000
Falcon Seaboard Drlg Co	Bge 4	dsl-elec	2700	Beth B-3661	2000	22,500
	11	stm	1000+	Alco BIW 12	1200+	17,000
	29	stm	1200+	Natl 3410 FE	2000+	20,000
Gulf Drlg Inc	2	gas	750	Wisn Spr Titan	1200	12,500
Wm Hawkins Drlg Co	5	dsl	200	Ideco PR 1050	900	15,000
Nickins Drlg Co	10	stm	—	Natl	—	17,000
Penrod Drlg Co	4	dsl	1500	Natl 130	1500	18,000
	17	gas-btne	1900	Brwstr N-12-A	1500	18,000
Rowan Drlg Co Inc	Bge 3	dsl-elec	2150	Emsco EDA	3455	20,000
Carnes W Weaver Drlg Co	Bge 1	dsl	2000	"Oilwell" 96	1700	16,000
C B Webster Drlg Co	7	stm	1600	Emsco ECA-10½	1200+	15,000
Webster Parish						
Crow Greyhound Drlg Co Inc	2	dsl	600	Brwstr N-45M	600	7,000
	3	dsl	1000	Brwstr N-7	825	8,000
Penrod Drlg Co	11	gas	1100	Natl 100	1400	12,000
Woolf & Magee Inc	1	stm	1000+	Natl 34-10FE	1200+	15,000
	8	gas-btne	1300	Beth Tornado	1300	15,000
Winn Parish						
Woolf & Magee Inc	7	gas-btne	800	Beth MC-450	800	11,000
	12	gas-btne	275	Beth S-45	275	10,000/2⅞"
MARYLAND						
Garrett County						
Delta Drlg Co	29	dsl	750	Emsco J-750	750	12,000
	33	gas-btne	624	Natl 50-A	450	7,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
MICHIGAN						
Allegan County						
Gordon Drlg Co	1	gas-LPG	250	"Oilwell" 64	225	4,000
	3	gas LPG	500	"Oilwell" 64-B	400	5,000
	7	gas-LPG	500	"Oilwell" 64-B	400	5,000
Arenac County						
Bernhardt Drlg Co	1	dsl	300	Failing 2500	300	3,500/2⅛"
Gordon Drlg Co	8	gas-LPG	600	Natl 50-A	500	9,000
Isabella County						
Gordon Drlg Co	10	gas-LPG	600	"Oilwell" 66	500	9,500
Hillsdale County						
Gordon Drlg Co	12	dsl	600	Wisn Giant	550	10,000
Manistee County						
Gordon Drlg Co	11	dsl	600	Wisn Roadair	500	10,000
St Clair County						
D B Lesh Drlg Co	1	dsl	200	Natl T-20	200	4,000
	2	dsl	320	Natl T-25	320	5,500
MISSISSIPPI						
Adams County						
Eagle Drlg & Dev Co	1	dsl	600	M-CSCO U-15	600	7,500
Larco Drlg Co	5	gas	800	"Oilwell" 76	1000	10,000
Martin Exploration Inc	1	gas	500	Crdwll 0	735	10,000
	4	dsl	500	M-CSCO U-15	600	8,500
Scooter's Drlg Serv	2	dsl	300	Brwstr N-4	300	4,500
Wilson Drlg Co	1	dsl	212	Ideco H-35-D	424	8,500/3½"
Forrest County						
Sunnyland Contr Co Inc	9	dsl	—	Crdwll D	450	8,000
Marshall R Young Drlg Co	8	—	1350	Wisn Titan	1122	14,000
Franklin County						
Marshall R Young Drlg Co	1	—	900	Natl 75	648	11,500
Hinds County						
Larco Drlg Co	2	dsl	1200	"Oilwell" 96	1200	14,000
	7	gas	900	"Oilwell" 96	1000	12,500
Issaquena County						
Thrasher Drlg Co Inc	1	gas-btne	350	M-CSCO U-15	600	8,500
Jasper County						
Zach Brooks Drlg Co	8	gas	2600	Brwstr N-12	2600	18,000
Jones County						
Zach Brooks Drlg Co	7	dsl	1350	Emsco U-1100	1350	14,000
Drlg & Expl Co of Del Inc	41	gas-gaso	1500	Emsco J-1100	1050	15,000
Jett Drlg Co Inc	106	dsl	1600	Brwstr N-95	1400	13,000
Larco Drlg Co	6	dsl	1200	"Oilwell" 96	1600	18,000
Marshall R Young Drlg Co	11	—	1350	Wisn Titan	1122	14,000
Lamar County						
Marshall R Young Drlg Co	12	—	740	Natl 50-A	558	10,000
Lawrence County						
Dorris Ballew Inc	8	dsl	1380	Natl 125	1725	16,000
Marshall R Young Drlg Co	5	—	1350	Wisn Titan	1122	14,000
Lincoln County						
Crown Rigs Inc	6	gas	900	Beth MC-450	600	10,000
Hawkins-Wilkins Prod Co	1	stm	—	Natl 3410 FE	—	15,000
Rimrock Tidelands Inc	12	gas-btne	1000	Natl 75	1215	12,000
Marshall R Young Drlg Co	3	—	900	Natl 75	830	11,500
	6	stm	1688	Natl 34	1480	16,000
	7	stm	1688	Natl 34	1480	16,000
Marion County						
Dorris Ballew Inc	4	dsl	760	Wisn Titan	1900	15,000
Pearl River County						
Crawford Drlg Co	3	stm	—	"Oilwell" 9	500	10,500
Crow Drlg & Prod Co	16	dsl	1100	Brwstr N-10	1100	12,000
Sunnyland Contr Co Inc	12	dsl	1120	Ideco H-525 SC	1000	10,000
Woolf & Magee Inc	11	gas-btne	275	Beth S-45	275	10,000/2⅞"
Pike County						
Arrow Drlg Co	18	gas	1260	Emsco 1250	—	14,000
Dorris Ballew Inc	1	dsl	760	Wisn Titan	1300	12,500
	2	dsl	760	Wisn Titan	1300	12,500
Hawkins-Wilkins Prod Co	2	dsl	—	Ideco PR-1050	900	15,000
Rimrock Tidelands Inc	8	dsl	900	Brwstr N-75	900	11,000
Sharkey County						
A W Williams Drlg Co Inc	2	dsl	495	Frnks 6000	495	8,500/4"
Simpson County						
Drlg & Expl Co of Del Inc	39	gas-gaso	1200	Emsco J-1100	1050	15,000
Jett Drlg Co Inc	110	dsl	1400	Brwstr N-95	1400	14,000
	111	dsl	2000	Natl 110	1500	15,000
Smith County						
Arrow Drlg Co	5	gas	1250	Emsco	—	14,000
Zach Brooks Drlg Co	9	gas-btne	1350	Brwstr N-95	1350	14,000
Larco Drlg Co	4	dsl	1700	"Oilwell" 96	1600	18,000

CONTINENTAL-EMSCO

A-SERIES rigs are as flexible as your drilling requirements



Power ends for A-Series rigs are designed for maximum *power flexibility* . . two, three or four engines . . 700 to 1800 horsepower . . variety of four pump drive arrangements. Four drawworks sizes provide a wide drilling range. This gives you latitude in assembling the minimum amount of rig equipment . . contract by contract . . to drill at the *lowest possible* cost per foot.

You'll save on rigging-up and tearing-down time too. Sections are easily, quickly assembled . . move in compact, low-cost truck loads.

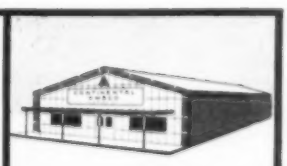
A-Series rigs open up more jobs for you . . make you *fully competitive* . . help you make more money on each job. Your Continental-Emsco man can give you detailed information . . call him today.

Nominal Input Horsepower for Hoisting
A-550 Rig—700 hp
A-800 Rig—1000 hp
A-1100 Rig—1400 hp
A-1500 Rig—1800 hp

DESIGNED TO CUT DRILLING COSTS.. LABOR COSTS.. INVESTMENT COSTS

CONTINENTAL-EMSCO

Serving the Oil and Gas Industries Worldwide



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CONTINENTAL-EMSCO COMPANY • A Division of The Youngstown Sheet and Tube Company • General Offices: Dallas, Texas
Export Division: 30 Rockefeller Plaza, New York, N. Y. • Continental-Emsco Company Limited • General Offices: Calgary, Alberta, Canada
Continental-Emsco Company C. A., Caracas, Venezuela • Plants: Houston and Garland, Texas; St. Albans, Herts., England • *Representatives in All Principal Oil Fields of the World*

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Rimrock Tidelands Inc	10	gas-btne	1400	Natl 110	1900	15,000
	11	gas-btne	1325	M-CSCO U-20	1900	20,000
	14	dsl	2000	Emsco A-1500	2000	20,000
Rowan Drlg Co Inc	8	gas-btne	1920	Natl 125	1920	18,000
Wayne County						
Drlg & Expl Co of Del Inc	37	gas-gaso	1200	Emsco GB-800	900	12,000
Rimrock Tidelands Inc	19	dsl	1410	Beth MC-950	1200	18,000
A W Williams Drlg Co Inc	3	dsl	300	Brwstr N-4	300	8,500/4"
Wilkinson County						
Woolf & Magee Inc	10	gas-btne	275	Beth Breeze	275	10,000/2⅛"
Yazoo County						
Rimrock Tidelands Inc	21	dsl	500	Emsco GB-500	600	10,000
MONTANA						
Big Horn County						
Hose-Austin Drlg Corp	2	dsl	300	Natl T-32	320	5,000
Carbon County						
Anschultz Oil Co Inc	11	gas	1000	Wlsn Giant	700	8,500
Dawson County						
Helmerich & Payne Inc	29	gas	950	Natl 75CA	1100	11,000
Hewit-Gulick Drlg Co	4	dsl	370	Natl T-32	356	6,000
Fallon County						
Zach Brooks Drlg Co	6	dsl	1300	Brwstr N-75	1300	12,500
Roden & McRae Drlg Co	3	dsl	900	Emsco GB-800	900	12,500
Signal Drlg & Expl Inc	5	gas-btne	—	Natl 80	1400	14,000
Glacier County						
Anschultz Oil Co Inc	6	dsl	300	Wlsn Giant	280	5,500
Musselshell County						
Hose-Austin Drlg Corp	1	dsl	350	Emsco GB-250T	450	6,000
Powder River County						
Oien Oil Corp	3	dsl	500	Natl T-20	280	5,000
Earl F Wakefield	5	gas-btne	550	Wlsn Gnt	550	6,500
Prairie County						
Hewit-Gulick Drlg Co	2	dsl	970	Natl 80	900	12,000
Rosebud County						
Fitzpatrick Drlg Co Inc	2	dsl	500	M-CSCO U-22	500	6,500
	3	dsl btne	300	Natl T-20	200	5,500
Richland County						
Rutledge Drlg Co	3	gas-btne	900	Beth 450	850	12,500
Sheridan County						
Helmerich & Payne Inc	33	gas	850	"Oilwell" 76	1100	11,000
Wibaux County						
Helmerich & Payne Inc	15	dsl	975	"Oilwell" 76	1000	11,000
Yellowstone County						
Hose-Austin Drlg Corp	3	gas	450	M-CSCO U-15	550	7,000
NEBRASKA						
Banner County						
Garvey Drlg Co	19	dsl	300	Wlsn Rdair	450	7,000/3½"
Lewis Bros Inc	3	dsl	376	M-CSCO U-15	476	8,000
Cheyenne County						
McDaniel Drlg Co	1	dsl	350	Ideco H-40	350	6,000
Kimball County						
Exeter Drlg Co	1	dsl	325	Emsco GA-350	425	7,000
Falcon Seaboard Drlg Co	9	gas-btne	325	M-CSCO U-15	450	8,500
Garvey Drlg Co	16	dsl	300	Wlsn Rdair	450	7,000/3½"
Herndon Drlg Co	2	gas	600	Natl 50-A	750	10,500
Love-Miller Drlg Co Inc	1	dsl	500	Wlsn Gnt Rdair	824	9,000
Murfin Drlg Co	5	dsl	450	Emsco 500	520	9,000
Don M Rounds Drlg Co Inc	1	dsl	530	Natl 50	530	6,500
	2	dsl	900	Crdwll 0	900	9,000
Richardson County						
Nemaha Oil Co	1	dsl	370	Frnks SAL 3000	370	4,500/3½"
NEVADA						
Churchill County						
Barry Well Drlg Co	2	dsl	200	—	—	2,500/3½"
Clark County						
Wells Drlg Co	2	dsl	325	Mobile Bitz 622	350	5,000
NEW MEXICO						
Chaves County						
Gardner Bros Drlg Co Inc	10	gas-btne	750	Natl 100	1050	12,500
A W Thompson Inc	8	gas	450	Beth 58	750	10,000
	9	gas	650	Clark PR-1000	1050	13,500
Eddy County						
Delta Drlg Co	9	gas-btne	936	Natl 100	800	12,000
Carl B King Drlg Co of Tex	5	gas-gaso	1000	Natl 100	1000	13,500
	7	gas-gaso	1200	Natl 100	1000	13,500
Leatherwood Drlg Co	6	gas	220	Wlsn Giant	—	4,500
Lee Drlg Co	1	gas-gaso	700	Natl 50	—	8,000
	2	gas-gaso	700	Natl 50	—	8,000
	4	gas-gaso	700	Natl 75	—	10,000
	6	gas-gaso	1050	"Oilwell" 76	—	13,000
Davey O'Brien Drlg Co Inc	4	gas-btne	280	Wlsn Spr	145	3,000
Parker Drlg Co	45	gas	—	Natl 125	1400	15,000
Rowan Drlg Co Inc	12	gas-btne	1260	Natl 100	1680	14,000
	16	gas-btne	504	Natl 50	660	7,000
Walters Drlg Co Inc	7	gas	175	Mayhew 1000	175	900"2⅛"
S P Yates Drlg Co	2	dsl	350	M-CSCO U-15	540	6,500
	3	dsl	350	Natl T-12	250	4,000
Lea County						
Alan Drlg Co	2	gas	350	Wlsn Mogul	185	4,000
Robert M Bass Drlg Contr	4	gas-LPG	300	Wlsn Gnt	300	5,500
Brantly Drlg Co Inc	3	gas	700	Brwstr N-75	750	11,000
Cactus Drlg Corp of Tex	1	gas-btne	1575	Natl 110	1575	15,000
	11	gas-btne	300	Brwstr N-4	460	5,000
Davidson Drlg Co Inc	C	btne	660	Emsco GC-500	660	8,500
Delta Drlg Co	6	gas-btne	800	Emsco J-750	750	9,500
Dillard-Waltermire Inc	9	gas	800	Natl 100	1200	13,500
Dual Drlg Co	6	gas	250	Emsco GA 250T	300	5,000
Gardner Bros Drlg Co Inc	14	gas-btne	750	Natl 100	1050	12,500
Hack Drlg Co	1	btne	—	M-CSCO U-15	412	8,500
Helmerich & Payne Inc	32	gas	1100	"Oilwell" 96	1100	14,000
	41	gas	1200	Natl 110	1500	15,000
Kerr-McGee Oil Ind Inc	7	gas	900	Natl 75	818	11,500
Carl B King Drlg of Tex	20	gas	2100	"Oilwell" 96-16	2100	20,000
La Mance Drlg Co	1	btne	350	Frnks 5000	—	5,000
Llano Drlg Co	5	gas	—	Natl 100	1050	14,000
Chas E Long Jr Inc	3	dsl	400	Emsco GA-500	520	10,000/3½"
Lowe Drlg Co	3	gas	1000	Natl 100	1000	12,500
	4	gas	1800	Natl 125	1800	17,500
	8	gas	1500	Natl 80	1500	15,000
Moran Oil Prod & Drlg Corp	4	gas	—	M-CSCO U-34	300	5,000
McAlester Fuel Co	2	btne-gas	—	Natl 100	1050	14,000
	5	btne-gas	—	Emsco J-1100	1050	14,000
B L McFarland Inc	6	gas	1000	Brwstr N-95	1050	14,000
McQueen & Stout Drlg Co	11	LPG	225	Crdwll RL	185	4,500
Parker Drlg Co	49	gas	—	Natl 125	1400	15,000
	51	gas	—	Natl 50	700	9,000
Pico Drlg Co	4	gas-btne	180	Wlsn Mogul	300	4,000
Rowan Drlg Co Inc	7	gas-btne	1260	Natl 100	1680	14,000
Sharp Drlg Co	18	gas	1350	Beth MC-950	1350	15,000
A W Thompson Inc	3	gas	650	Emsco 800	1050	13,500
	5	gas	650	Beth 810	1050	13,500
	6	gas	600	Beth 450	1050	11,000
	12	gas	350	Emsco 350	600	7,000
Western Serv Drlg Co Inc	8	gas- tbne	600	Beth MC-650	700	11,000
	11	gas-btne	1000	Beth 810	1100	11,000
Carl J Westlund Inc	5	gas-btne	650	Natl 50	—	8,500
S P Yates Drlg Co	1	dsl	350	M-CSCO U-34	350	5,000
Mora County						
B F Allison Drlg Co	4	gas-btne	900	Brwstr N-75	900	11,000
Rio Arriba County						
Rutledge Drlg Co	2	gas-btne	675	Beth M-58	850	10,000
San Juan Drlg Co	15	gas	570	M-CSCO U-15	570	7,500
Roosevelt County						
Brantly Drlg Co Inc	8	gas	675	Beth 450	870	11,500
Lowe Drlg Co	1	gas	500	M-CSCO U-15	500	7,500
	2	gas	750	Natl 75	750	10,000
San Juan County						
Anschultz Oil Co Inc	2	dsl	900	Wlsn Giant	560	8,500
Brannon & Murray Drlg Co	1	gas-LPG	550	Brwstr N-55	550	8,500
	2	gas-LPG	550	Emsco GA-350	550	6,500
	3	gas-LPG	350	Brwstr N-4	250	5,000
Carroll Drlg Co Inc	6	dsl	—	M-CSCO U-15	—	7,500
	8	gas-btne	—	Natl 75	—	9,500
	10	gas-btne	—	Emsco 3500	—	6,500
D-K Drlg Co	2	gas	675	Natl 50	675	7,500
Exeter Drlg Co	3	btne	630	Natl 50-A	630	8,500
Fleeger Drlg Inc	1	dsl	325	Beth Twister	600	8,500
	5	dsl	360	Frnks	500	5,000
	6	dsl	450	M-CSCO U-15	600	8,500
	7	dsl	360	Beth 45-E	500	5,000
Foree Drlg Co	1	gas-btne	325	M-CSCO U-34	300	4,500
	3	gas-btne	325	M-CSCO U-15	600	7,500
	5	btne	350	"Oilwell" 52-T	426	6,000
Gardner Bros. Drlg Co Inc	9	gas-btne	450	M-CSCO U-15	675	7,000
	17	gas-btne	550	Natl 50-A	700	8,500
	19	gas-btne	185	Crdwll R	200	3,300
	21	—	250	Wilson Mogul	250	4,500
Herndon Drlg Co	4	gas	480	Emsco G-450	630	7,000
H B Lynn Drlg Corp	1	gas-btne	700	Natl 50	—	7,500
	2	gas-btne	700	Natl 50	—	7,500
	3	gas-btne	700	Natl 50	—	7,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
San Juan Drlg Co	3	gas	570	Natl 50	570	7,500
	4	gas	570	Natl 50	570	7,500
	8	gas	570	Natl 50	570	7,500
	10	gas	570	Natl 50	570	7,500
	14	dsl	340	Frnks SA-4500	400	5,000
Sierra County						
Parker Drlg Co	59	gas	—	Natl 75	1000	11,000
NEW YORK						
Schuyler County						
Gordon Drlg Co	S-7	dsl	300	Crdwll S	300	4,500
NORTH DAKOTA						
Bottineau County						
Calvert Drlg Inc	22	gas-btne	320	Ideco H-35	330	5,500
Cardinal Drlg Co (Bismarck)	1	dsl	320	Emsco GB-250	320	5,500
	2	dsl	320	Natl T-20	320	5,000
	3	dsl	280	Frnks	280	3,000
	4	dsl	320	Natl T-20	320	5,000
Exploration Drlg Co	6	gas	310	Beth S-50	225	5,500
Burke County						
Anschutz Oil Co Inc	5	dsl	300	Wisn Giant	280	5,500
Cactus Drlg Corp Ltd	1	gas-btne	450	Brwstr N-55	450	7,000
	2	gas-btne	675	M-CSCO U-15	675	8,500
Calvert Drlg Inc	23	dsl	350	Ideco H-525	600	8,500
Helmerich & Payne Inc	8	gas	600	Natl 55	800	9,000
Divide County						
Calvert Drlg Co	24	gas-btne	600	M-CSCO U-15	600	9,000
	25	gas-btne	1050	Beth 810	1100	12,500
Signal Drlg & Expl Inc	3	dsl	370	M-CSCO U-36A	420	7,500
McHenry County						
Exploration Drlg Co	9	gas	310	Beth S-50	225	5,500
McKenzie County						
Anschutz Oil Co Inc	14	gas	900	Brwstr N-7	600	10,000
Gabe McCall Drlg Co	3	gas	1200	Natl N-80	1200	12,000
Penrod Drlg Co	25	gas-btne	1400	M-CSCO U-20	1400	14,000
	31	dsl	920	Brwstr N-75	830	11,000
Rowan Drlg Co Inc	15	gas-btne	1140	Natl 75	1503	11,000
	23	gas-btne	1140	Natl 75	1503	11,000
Rutledge Drlg Co	1	gas-btne	960	Beth 810	1257	15,000
Stark County						
Anschutz Oil Co Inc	15	dsl	1000	"Oilwell" 76	1000	12,000
Rowan Drlg Co Inc	5	gas-btne	840	Natl 75	1120	11,000
Ward County						
Anschutz Oil Co Inc	12	gas	830	Brwstr N-45	530	7,000
Williams County						
Calvert Drlg Inc	26	gas-btne	1380	Natl 80-B	1380	14,000
Penrod Drlg Co	5	dsl	1200	Emsco A-1100	1400	15,000
	19	dsl	795	Brwstr N-7	700	10,000
Rowan Drlg Co Inc	27	gas-btne	1350	Natl 125	1530	15,000
OHIO						
Medina County						
Delta Drlg Co	10	dsl	560	M-CSCO U-15	560	7,000
Wayne County						
D J Branyan Co	1	dsl	600	Wichtex E-75	145	3,000
Walter W Willis	2	dsl	278	Natl T-12	237	4,500
OKLAHOMA						
Alfalfa County						
Lohmann-Johnson Drlg Co Inc	8	dsl	300	Natl 32	550	7,500
Tommy Ward Drlg Co	1	gas-btne	300	M-CSCO U-35	426	7,000
Beaver County						
Arrow Drlg Co	20	gas	460	Emsco 350	—	7,000
Big Chief Drlg Co	24	gas	750	M-CSCO U-15	800	9,500
	27	gas	760	JS&G Spad Spr	760	9,000
	33	gas	1250	Natl 55	1250	11,000
Calvert Drlg Inc	21	dsl	350	Ideco H-35	260	6,500/4"
D & M Drlg Co Inc	1	gas-btne	550	Natl 50	550	7,500
Falcon Seaboard Drlg Co	21	gas-btne	600	M-CSCO U-15	600	8,500
	38	gas-btne	600	Wisn Atlas	600	8,500
	39	gas-btne	600	Emsco G-500	600	8,500
Carl B King Drlg Co of Tex	11	gas-gaso	900	Natl 75	900	11,000
Midwestern Drillers Inc	2	dsl	320	M-CSCO U-15	600	7,500
	3	dsl	370	M-CSCO U-15	750	8,500
	7	dsl	370	M-CSCO U-15	750	8,500
Patco Drlg Contr	3	gas	450	M-CSCO U-15	—	9,000
R W Rine Drlg Co	3	gas-btne	520	Brwstr-55	600	8,500
Viersen & Cochran	5	gas	500	Natl 50	650	9,000
Wagner & Wyant Drlg Co Inc	4	gas-btne	500	M-CSCO U-15	700	9,000
Beckham County						
Helmerich & Payne Inc	47	gas-btne	2000	"Oilwell" 96-16	2000	20,000
Bryan County						
Chester H Westfall Drlg Co	1	gas-gaso	625	M-CSCO U-15	700	10,400
Caddo County						
Arrow Drlg Co	25	gas	840	Ideco 1000	—	10,000
Calvert Drlg Inc	27	—	—	Wisn Spr	—	12,500
Glendale Drlg Co	1	gas-gaso-btne	320	M-CSCO U-10	330	5,000
Graham Drlg Co (Okla)	1	gas-btne	235	Wisn Mogul	285	5,000
G H Ray Well Serv	1	prop-gas	200	Wilson	200	4,500
Sherin Drlg Co	3	gas-gaso	500	M-CSCO U-15	600	8,000
Carter County						
Graves Drlg Co	1	dsl	300	Frnks 4000-A	330	3,500
	2	gas	165	Frnks 2500	125	2,000
Holliman Drlg Co	1	gas	500	M-CSCO U-15	900	7,500
Ward S Merrick	1	gas	300	Wisn Giant	—	5,000
Nelson-Spain Drlg Co	3	gas	225	M-CSCO U-34	400	4,500
Perkins Drlg Co	2	gas-btne	—	M-CSCO U-15	675	8,500
	3	gas-btne	400	Beth S-60	370	7,500
Sherin Drlg Co	2	gas-gaso	500	M-CSCO U-15	600	8,000
	5	gas-gaso	750	Natl 55	750	9,000
J D Speer	1	dsl	104	Wisn Spr	104	2,000/3½"
Cimarron County						
Schafer Drlg Co	4	gas-gaso	200	M-CSCO U-34	200	6,000
Cleveland County						
Davon Drlg Co	3	gas-LPG	500	Brwstr N-7	750	10,000
Garr-Woolley Co	2	gas-btne	255	Emsco 350	378	7,000
Goff-Leeper Drlg Co	3	gas	450	M-CSCO U-15	450	8,000
Kirkpatrick Oil Co	4	gas	300	Wisn Giant	504	10,500
Parker Drlg Co	5	gas	—	Natl 50	700	9,000
Coal County						
Falcon Seaboard Drlg Co	26	dsl	225	Beth Twister	212	6,500
Goff-Leeper Drlg Co	2	gas	225	Brwstr N-4	350	6,000
Reed Drlg Co Inc	2	gas-gaso	—	Crdwll D	410	5,500
Sherin Drlg Co	4	gas-gaso	1000	Natl 100	1050	12,000
Cotton County						
Bolin Oil Co & D H Bolin	5	gas	225	Wisn Mogul	190	4,000
Creek County						
Bodard Drlg Co	1	gas	225	M-CSCO U	185	4,500
Davon Drlg Co	4	gas-LPG	200	Brwstr N-2	290	6,500/2⅛"
Doak Drlg Co	2	btne-gas	270	Natl T-20	250	4,500
Jonco Drlg Co	2	gas-gaso	300	Crdwll S	175	5,000
Mesker Drlg Co	1	gas	214	Joy 300	170	2,500
Reed Drlg Co Inc	6	gas-gaso	240	Natl T-12	180	4,500+
Wade Drlg Co Inc	1	dsl	225	Crdwll L	185	3,500
Custer County						
Big Chief Drlg Co	2	gas	1875	Natl 125	1815	16,000
Viersen & Cochran	9	gas	1200	Emsco J-1250	1590	18,000
Dewey County						
Calvert Drlg Inc	28	—	—	Natl 80-B	1650	12,500
Falcon Seaboard Drlg Co	15	gas-btne	1100	M-CSCO U-10	1200	16,000
Ellis County						
Helmerich & Payne Inc	24	gas	950	Natl 80	1100	11,000
	36	gas	5000	Emsco GB-500-52	700	9,000
	46	gas	500	Emsco GB-500-52	700	9,000
Keating Drlg Co	13	gas-gaso	—	—	1000	12,000
J S Montgomery	3	gas	1100	Natl 80	1100	12,000
Parker Drlg Co	56	gas	—	Natl 50	700	9,000
Garfield County						
Goe Drlg Inc	2	gas	200	Wisn Mogul	170	4,000
Hayward Drlg Co	1	gas	200	Wilson	125	2,500
O'Rourke-McGirl Drlg Co	1	gas-btne	—	M-CSCO U-10	450	6,000
Garvin County						
Big Chief Drlg Co	5	gas	1545	Emsco 1250	1545	15,000
	30	gas	1545	Ideco 1050	1515	15,000
Big X Drlg Co Inc	2	gas-btne	750	Natl 55	750	10,000
Garvey Drlg Co	6	dsl	275	M-CSCO U-15	640	8,500
	21	dsl	500	M-CSCO U-15	640	8,500
Goff-Leeper Drlg Co	1	gas	800	Brwstr N-75	800	12,000
Perkins Drlg Co	4	gas-btne	1200	Beth 650	1200	12,000
Sherin Drlg Co	1	gas-gaso	500	M-CSCO U-15	600	8,000
Grady County						
Big Chief Drlg Co	35	gas	2610	Natl 110	2610	16,000
Falcon Seaboard Drlg Co	Z-3	gas-btne	1200	Beth 950	1600	18,000
Helmerich & Payne Inc	44	gas	1200	"Oilwell" 96	1500	15,000
Dick Wegener Drlg Co	4	gas-dsl	1900	Natl 130	1900	22,000
Grant County						
Barrett Petroleum Co	2	gas-gaso	—	Natl 50	450	6,800
	5	gas-gaso	—	Brwstr N-7	750	8,500
Branyan Drlg Co	2	dsl	700	Beth	700	9,000
Calvert Drlg Co	15	dsl	260	Ideco H-35	260	5,000

Mast Down... Well Completed!
Operators and contractors in the San Juan Basin require highly portable drilling rigs for fast moves over difficult terrain. Here, a rig equipped with a Mid-Continent U-36-A drawworks has completed a gas well near Blanco, New Mexico, and is being prepared for movement to a new location. The highly portable U-36-A is ideal for the Four Corners area, providing convenient movement, fast drilling, and extra depth capacity. A single package rig when skid mounted, the U-36-A can also be trailer mounted with the mast. For drilling to depths requiring 300 to 600 H.P. input, and high portability, equip your rig with a Mid-Continent U-36-A drawworks. See your Mid-Continent representative for full details.
DW1-9
MID-CONTINENT SUPPLY CO.
MID-CONTINENT BUILDING • FORT WORTH, TEXAS
Export Division: 45 Rockefeller Plaza, New York 20, N. Y. Cable: MIDCUMPORT NYK
THE WORLD'S LARGEST INDEPENDENT OIL FIELD SUPPLY COMPANY

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Davon Drlg Co	1	gas-LPG	250	Brwstr N-4	200	6,000/3½"
	2	gas-LPG	380	Brwstr N-4	320	6,500
Dudley & Heath Drlg Co	7	dsl	265	Brwstr N-4	320	6,000
Viersen & Cochran	12	gas	325	Natl T-25	225	5,500
	14	gas	325	Natl T-25	225	5,500
Harmon County						
E W Moran Drlg Co	2	gas	500	Wlsn Gnt	650	7,500
Harper County						
Calvert Drlg Inc	18	gas-btne	—	M-CSCO U-15	585	8,500
Falcon Seaboard Drlg Co	37	gas-btne	600	M-CSCO U-15	600	8,500
General Drlg Co	1	—	—	M-CSCO U-15	—	9,000
Summit Drlg Corp	3	gas	—	Emsco 450	450	7,000
Viersen & Cochran	1	gas	350	Natl 50	450	8,000
Johnston County						
Helmerich & Payne Inc	38	gas	950	Natl 80	1100	11,000
Parker Drlg Co	55	gas-elec	—	Emsco 750	2000	10,000
Kay County						
John Heard & Co Inc	2	gas-LPG	270	Natl T-12	212	3,500
Dave Morgan Drlg Co	—	LPG-gas	350	Natl T-32	320	6,000
Pete Morris Drlg Co	1	dsl-gas	550	Wlsn Gnt	550	6,000
The Novak Drlg Co	3	gas	265	Brwstr N-45	—	5,000
Target Drlg Corp	1	gas-btne	225	M-CSCO U-34	195	5,000
Tennant Drlg Co	1	gas-btne	400	Frnks 6000	400	6,000
						8,500/3½"
Kingfisher County						
Calvert Drlg Inc	19	dsl	350	M-CSCO U-15	600	8,500
Lincoln County						
Folk Drlg Co	1	dsl	200	Crdwll RL	200	4,000
Patco Drlg Contr	1	dsl	300	M-CSCO U-34	—	4,500
Sabre Drlg Co	4	gas-LPG	225	Brwstr N-3	160	3,500 4"
Logan County						
Big Chief Drlg Co	1	gas	450	JS&G Spad "Super"	450	6,500
Davon Drlg Co	5	gas-LPG	400	Brwstr N-45	320	7,500
Garr-Woolley Co	1	gas-btne	185	Emsco 300	280	5,500
Nuckolls-Bell Drlg Co	2	dsl	300	Ideco H-40	352	7,500
Summit Drlg Corp	2	dsl	—	Frnks SAL 5000	800	5,000
Warren Drlg Co	1	gas	395	Natl T-32	360	6,500
Love County						
Falcon Seaboard Drlg Co	24	gas-btne	1000	Beth 950	1365	16,000
	32	gas-btne	1050	Beth 650	1155	16,000
	35	gas-btne	600	Brwstr N-7	600	8,500
Marshall County						
Nelson-Spain Drlg Co	1	gas	450	M-CSCO U-15	450	6,500
	2	gas	620	Wlsn Gnt	620	7,500
McClain County						
A & P Drlg Co Inc	2	gas-gaso-btne	500	Emsco GB-500	500	8,000
Big X Drlg Co Inc	1	gas-btne	750	Beth ME-450	750	10,000
Bryant-Hayward Drlg Co	1	gas	675	Natl 50	675	8,500
	2	gas	675	Natl 50	675	8,500
Falcon Seaboard Drlg Co	8	gas-btne	450	Beth 450	900	10,000
	28	gas	1200	Beth 090	1050	16,000
Fleeger Drlg Inc	2	dsl	320	Wlsn Roadair	700	8,500
Garr-Woolley Co	4	gas-btne	1020	Emsco 500-GC	510	10,000
Goff-Leeper Drlg Co	4	gas	850	Wlsn Gnt	850	12,500
	5	gas	850	Ideco H 7-11	850	13,000
Hap Drlg Co	1	gas	350	Emsco GB-500	550	8,000
Holliman Drlg Co	5	dsl	825	Emsco GB-800	1000	11,000
Nuckolls-Bell Drlg Co	3	dsl	600	Ideco H-525	704	9,000
Parker Drlg Co	30	gas	—	Natl 50	700	9,000
	34	gas	—	Natl 75	800	10,000
	37	gas	—	Natl 100	1400	14,000
	38	gas	—	Natl 100	1000	14,000
Viersen & Cochran	2	gas	500	Natl 55	650	10,500
	3	gas	600	Natl 75CA	650	10,500
	4	gas	600	Natl 75	650	10,500
	8	gas	980	Emsco J-1000	1250	14,000
Chester H Westfall Drlg Co	2	gas-gaso	625	M-CSCO U-15	700	10,400
	3	gas-gaso	625	M-CSCO U-15	700	10,400
Noble County						
Barrett Petroleum Co	4	dsl	—	M-CSCO U-10	350	5,800
Hap Drlg Co	2	gas	300	Brwstr N-4	200	5,000
The Novak Drlg Co	2	gas	300	M-CSCO U-10	—	6,500
Patco Drlg Contr	2	dsl	300	M-CSCO U-15	—	7,500
Reed Drlg Co Inc	1	gas-gaso	220	M-CSCO U-34	235	5,000
Summit Drlg Corp	1	dsl	—	Emsco 450	480	7,000
Wade Drlg Co Inc	3	dsl	325	Crdwll L	225	4,500
Warren Drlg Co	2	dsl	320	Ideco H-30S	300	5,000
Nowata County						
Overby Drlg Co Inc	1	dsl-btne	180	Mayhew 1000	1000	1,000
Okfuskee County						
Sabre Drlg Co	2	dsl	330	M-CSCO U-34	300	5,000 4"
Oklahoma County						
Garr-Woolley Co	3	gas-btne	320	Emsco 500-GB	510	9,500
Sabre Drlg Co	3	dsl	285	M-CSCO U-36	560	7,500/4"
Viersen & Cochran	7	gas	1200	M-CSCO U-712A	1075	15,000
Wolfe Drlg Co	12	gas-btne	342	Natl T-20	342	4,500
Okmulgee County						
Twinoak Drlg Co	1	dsl	190	Frnks	190	3,000
Osage County						
Delaware Drlg Co	3	dsl	160	Crdwll AL	150	4,000/2⅞"
Doak Drlg Co	3	btne-gas	270	Natl T-20	250	4,500
Falcon Seaboard Drlg Co	19	gas-btne	185	M-CSCO U-34	194	5,000
Goe Drlg Co	3	dsl	225	Carson	195	3,000
John Heard & Co Inc	1	gas-LPG	240	Brwstr N-4	212	3,500
R L Horn & Sons Drlg Co	2	dsl	185	Frnks Sr Clpr	185	4,000
	3	gas	185	Brwstr N-3	165	5,000
Al Johnson Drlg Co	2	btne	325	Mayhew	200	3,500
Mesker Drlg Co	2	gas	185	Joy 300	160	2,500
The Novak Drlg Co	1	gas	225	Brwstr N-4	—	3,500
Reed Drlg Co Inc	3	gas-gaso	180	M-CSCO U-34	180	3,200
Pawnee County						
Roy Lawrence Drlg Co	1	dsl	350	Frnks Comet	240	5,500/3½"
Payne County						
Dudley & Heath Drlg Co	6	dsl	265	Crdwll S	320	5,500
Pottawatomie County						
Barrett Petroleum Co	3	dsl	—	Wlsn Gnt	300	5,500
Johnson-Bates Drlg Co	1	gas	245	M-CSCO U-34	300	4,500
	2	gas	300	M-CSCO U-34	300	5,000
Viersen & Cochran	13	gas	325	Natl T-16	175	5,200
Seminole County						
Don Clawson	1	gas-btne	240	Brwstr N-4	185	4,500
R L Horn & Sons Drlg Co	1	dsl	185	Frnks Comet	300	5,500
Jonco Drlg Co	1	gas-gaso	300	Emsco 160	200	5,000
Melco Drlg Co	1	btne	265	Brwstr N-35	185	5,000
	2	btne	265	Brwstr N-35	185	5,000
R W I T Drlg Co	1	gas-LPG	150	Crdwll	150	3,000/3½"
Reed Drlg Co Inc	4	gas-gaso	300	M-CSCO U-34	290	5,000
Troup & Suttles Inc	2	gas-gaso	200	Wilson	370	5,000
Stephens County						
A & P Drlg Co Inc	1	gas-gaso-btne	450	Emsco G-450	450	7,000
Bryant-Hayward Drlg Co	4	gas	900	Brwstr N-75	900	12,000
R A Davenport Drlg Contr	1	gas-btne	145	Wichtex R-4	145	2,500
Goldsmith Drlg Co	2	—	400	Natl 50	—	8,000
Holliman Drlg Co	2	gas	350	M-CSCO U-15	550	7,500
	4	gas	255	M-CSCO U-15	500	7,500
Nelson-Spain Drlg Co	4	gas	650	M-CSCO U-15	650	9,000
Parker Drlg Co	60	gas-elec	—	Natl 34 x 10	2000	25,000
Pierco Drlg Co	1	gas-LPG	400	Wlsn Mogul	165	4,200
Viersen & Cochran	11	gas	1525	Natl 110	1530	18,500
Terrell County						
Helmerich & Payne Inc	48	gas-btne	1200	Natl 110	1300	15,000
Texas County						
Graham-Michaelis Drlg Co	1	dsl	275	Beth Twister	500	6,500
	3	dsl	300	Crdwll S	175	5,000
Holm Drlg Co	6	dsl	750	Wlsn Roadair	600	8,500
Lynn Drlg Co	2	gas-btne	425	Natl 75	700	10,000
	4	gas-btne	450	Natl 50	675	8,000
Moran Bros Inc	2	gas	700	Emsco GA-500	750	9,500
R W Rine Drlg Co	4	dsl	620	Brwstr N-75	750	9,500
Earl F Wakefield	4	gas-btne	750	Wlsn Gnt Rdair	750	9,500
	6	dsl	960	Wlsn Atlas Rdair	960	13,000
Washington County						
Overby Drlg Co Inc	3	btne	250	Mayhew 2000	250	2,000
Woods County						
Kirkpatrick Oil Co	1	gas	300	Beth S-60	336	7,500
Woodward County						
Barrett Petroleum Co	1	gas-gaso	—	Natl 50	450	6,800
Big Chief Drlg Co	36	gas	800	Natl 55	800	11,000
Viersen & Cochran	10	gas	325	Natl 50	450	8,500
PENNSYLVANIA						
Clearfield County						
Delta Drlg Co	24	dsl	670	Emsco GC-500	500	8,500
	30	dsl	670	Emsco G-500	500	8,500
Fairman Drlg Co	1	gas-btne	500	Beth M-58	600	10,000
	2	gas-btne	500	"Oilwell" 66	600	9,000
	3	gas-btne	500	Wlsn Gnt	600	9,000
S W Jack Drlg Co	3	gas	650	M-CSCO U-15	650	8,500
Clinton County						
Delta Drlg Co	27	dsl	380	Emsco GA-350	350	6,000
Elk County						
Delta Drlg Co	39	gas-btne	500	Natl 75	1000	9,500

A Real Brake

FOR YOUR DRAW WORKS-

M-C-M BRAKE FLANGES!

- Forged seamless
- Heat treated
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- Uniform hard wearing surface
- Forged steel
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Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Indiana County						
Delta Drlg Co	34	gas-btne	800	M-CSCO U-15	600	8,000
Lohmann-Johnson Oil Co Inc	2	gas	500	"Oilwell" 76	750	10,000
Somerset County						
S W Jack Drlg Co	1	gas	635	M-CSCO U-15	635	8,500
SOUTH DAKOTA						
Branyan Drlg Co	1	dsl	600	Frnks 6000	600	6,000
Harding County						
A L Schlaikjer	1	gas	832	Wisn Gnt Rdair	832	9,000
Signal Drlg & Expl Inc	1	gas-btne	800	M-CSCO U-40	800	10,000
TEXAS						
Anderson County						
Ace Drlg Co	4	gas	680	Emsco G-500	500	8,500
Trant Drlg Co	1	dsl	500	M-CSCO U-15	1200	10,000/4"
	2	dsl	500	Ideco M-10,000	1000	12,000
Travis Ward Drlg Co	1	dsl	600	Wisn Gnt	300	6,500
W W Wise Drlg Inc	2	dsl	550	Beth MC-450	550	9,000
Andrews County						
Arrow Drlg Co	17	gas	1260	Emsco 1250	—	14,000
	24	dsl	1200	Emsco 1000	—	14,000
Henry Black Drlg Co Inc	3	gas	350	Natl 50	450	8,500
	4	gas	850	Natl CB-75	900	10,750
	6	gas	400	M-CSCO U-15	500	8,500
	7	gas	1050	Natl 100	1350	14,000
Cactus Drlg Corp of Tex	3	gas-btne	800	Natl 80-B	—	12,500
	4	gas-btne	1050	"Oilwell" 76	1050	12,500
	9	gas-btne	800	Brwstr N-75	—	12,500
M J Delaney Co	27	gas-btne	500	Beth 450	850	11,000
	29	gas-btne	500	Beth 450	750	11,000
Fryer & Hanson Drlg Co	10	gas-btne	225	M-CSCO U-34	275	4,500
	11	gas-btne	1200	Beth M-58	1200	12,000
Gardner Bros Drlg Co Inc	5	gas-btne	500	Natl 75	675	9,000
	16	gas-btne	1000	Natl 125	1400	15,000
O E Hall Drlg Co	1	gas	320	M-CSCO U-15	700	8,000
Helmerich & Payne Inc	39	gas	1100	"Oilwell" 96	1300	14,000
King-Phillips Inc	1	gas-gaso	695	Natl 50	—	7,500
	4	gas	700	Beth S-45E	350	6,500
Carl B King Drlg Co of Tex	10	gas-gaso	1000	Natl 75	1000	12,500
La Mance Drlg Co	2	btne	700	M-CSCO U-15	—	9,500
	3	btne	550	"Oilwell" 64	—	6,500
Llano Drlg Co	2	gas	—	Natl 100	975	14,000
	3	gas	—	"Oilwell" 96	975	14,000
Lowe Drlg Co	5	gas	750	Natl 75	750	10,000
	6	gas	500	M-CSCO U-15	500	7,500
	10	gas	1000	Wilson	1000	12,500
	11	gas	1250	Natl 100	1250	12,500
Moran Oil Prod & Drlg Corp	2	gas	—	Natl 75	750	10,000
Dale Mount Drlg Inc	114	gas	570	Crdwll	570	7,000
	115	gas	1200	Emsco	1200	12,000
B L McFarland Inc	5	gas	700	Brwstr N-75	850	12,000
	8	gas	700	Brwstr N-75	850	12,000
	12	gas	500	Brwstr N-55	575	8,000
McQueen & Stout Drlg Co	15	LPG	225	Crdwll RL	185	4,500
Davey O'Brien Drlg Co Inc	1	gas-btne	700	Emsco GA-500	700	8,500
Parker Drlg Co	4	gas	—	Natl 100	1400	14,000
	41	gas	—	Natl 100	1400	14,000
	42	gas	—	Natl 100	1400	14,000
	43	gas	—	"Oilwell" 96	1400	15,000
	47	gas	—	Natl 100	1400	14,000
	53	gas	—	Natl 75	1000	11,000
	54	gas	—	Natl 125	1400	20,000
	58	gas	—	Natl 100	1400	14,000
Fred Pool Drlg Co	2	gas	870	M-CSCO U-15	870	8,500
Robinson Bros Drlg Co	4	gas	300	Brwstr N-45	450	6,500
Rowan Drlg Co Inc	22	gas-btne	600	Natl 50	766	7,000
Sharp Drlg Co	20	gas	1350	Beth MC-950	1350	15,000
	34	gas	1350	Beth 1013	1350	16,000
	40	gas	1350	Beth Tornado	1350	14,000
	46	dsl	1500	Natl 125	1500	18,000
	47	gas	900	Beth M-58	900	12,000
A W Thompson Inc	2	gas	650	Beth 10-13	1650	16,000
	7	gas	650	Beth 450	1050	11,000
Tri-Service Drlg Co	5	gas	825	"Oilwell" 76	825	10,000
Warton Drlg Co	2	gas	600	Natl 50	700	8,500
Western Drlg Co Inc	21	btne	650	Natl 100	325	10,000
Westlund Drlg Co	3	gas-btne	600	M-CSCO U-15	—	8,500
Aransas County						
Layton Brown Drlg Co	Bge 4	dsl	1850	"Oilwell" 96	1100	16,000
Camden Drlg Co	Bge 2	dsl	600	Natl T-32	300	7,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Archer County						
Jack Grace Drlg Co	19	gas-btne	255	Wlsn Gnt	350	5,000
Hack Drlg Co	3	btne	—	M-CSCO U-15	412	8,500
Sheets & Walton Drlg Co	3	pwr	365	Brwstr N-4	285	5,000
Atascosa County						
Buzzini Drlg Co	8	gas-btne	1920	Wlsn Titan	1210	13,000
	9	gas-btne	1150	Wlsn Titan	1210	13,000
Gilmour Drlg Co	2	gas	800	Natl 50	600	8,500
Steen Drlg Co	4	gas-btne	1350	Ideco 1050	1350	16,000
Austin County						
Howard Parker Co	5	gas-btne	600	M-CSCO U-15	900	10,500
Baylor County						
A D McDuffie	1	btne	165	Big Four	145	2,500
Bee County						
Allen & Morris	3	stm	500	Emsco H-46M	1200	11,000/5"
Falco Drlg Co	1	gas	750	Brwstr N-45	400	6,500
	2	gas	600	Wlsn Gnt	650	8,000
Harkins & Co	7	dsl	600	M-CSCO U-15	600	9,500
Hunt Drlg Co Inc	4	gas	846	Emsco GB-250	306	7,000
J & C Drlg Co	8	gas-btne	800	Beth 650	800	12,000
Kirkwood Drlg Co	12	gas-btne	590	Ideco H-40	460	9,000
Bexar County						
J E Hiller	3	dsl	800	Crdwll KM-250	400	8,500/3½"
Walters Drlg Co Inc	9	gaso	130	Mayhew 1000	130	800/2+"
Borden County						
Cactus Drlg Corp of Tex	5	gas-btne	700	Natl 75	700	10,000
	8	gas-btne	675	Brwstr N-7	675	9,000
Empire Drlg Co	3	gas	500	Brwstr N-75	975	11,000
Falcon Seaboard Drlg Co	36	gas-btne	1100	Natl 100	1100	12,500
Fortune Drlg Corp	2	gas	300	M-CSCO U-15	590	7,500
John Grappe Drlg Co	3	gas-btne	1000	L C Moore	900	13,000
Johnn Drlg Co	8	gas	500	Brwstr N-75	700	10,000
Chas E Long Jr Inc	2	dsl	250	Emsco GA-500	520	10,000/3½"
Milhoan Drlg Co	6	gas	600	M-CSCO U-15	—	8,000
Rheay & Reynolds Drlg Co	3	gas	400	M-CSCO U-15	1200	6,500
	4	gas	350	Natl 50	1200	7,000
	5	gas	350	Natl 75	1200	7,000
Warton Drlg Co	4	gas	950	Emsco J-750	1000	12,000
Brazoria County						
Big "6" Drlg Co	3	gas-btne	500	Crdwll Tlrg	500	6,000
Clegg & Hunt	7	dsl	—	Natl 75	880	11,000
Dillard-Waltermire Inc	3	stm	800	Natl 23-9FM	1000	12,000
	5	stm	800	Natl 23-9FM	1000	12,000
Hunt Drlg Co Inc	2	stm	1200+	Emsco H46M	1200+	11,000
	5	gas	1680	Beth MC-650	1200	14,000
Mac Drlg Co	12	stm	500	Natl 23-9FED	1000+	20,000
Howard Parker Co	2	gas-btne	500	Crdwll D	750	9,500
	4	gas-btne	330	Crdwll D	750	9,500
Penrod Drlg Co	18	stm	—	Emsco UBLS-54	—	14,000
Brewster County						
Hissom Drlg Co	4	gas	400	M-CSCO U-34	350	5,000
Brooks County						
Chiles Drlg Co	2	dsl	300	Ideco H-40	300	6,000
Stice Drlg Co	1	btne-gas	496	M-CSCO U-15	—	7,500
Well Drillers Inc	1	gas-gaso-btne	1140	Natl 75	870	9,500
Caldwell County						
MIM Drlg Corp	1	dsl	500	Frnks SA-4500	300	5,000
Calhoun County						
Layton Brown Drlg Co	3	stm	—	—	1050	10,000
Callahan County						
Low Drlg Co	3	btne	—	Wilson	165	2,500
Sojourner Drlg Corp	5	btne	225	Natl T-8-S	—	3,250
Woodson Prod Co	2	gas	600	M-CSCO U-15	900	8,500
Carson County						
Cree Drlg Co Inc	7	gas-btne	185	Emsco 250	300	4,500
Keating Drlg Co	15	gas-gaso	—	—	675	9,000
Schafer Drlg Co	6	gas-gaso	200	M-CSCO U-34	200	5,000
Cass County						
Butler-Johnson Inc	3	gas-btne	400	Brwstr N-45	400	7,000
M J Delaney Co	28	gas-btne	500	"Oilwell" 96	1000	14,000
Chambers County						
Brewster-Bartle Drlg Co Inc	3	dsl	—	"Oilwell" 96	1500	16,000
	10	dsl	—	"Oilwell" 76	—	11,000
	15	gas	—	Emsco	—	10,000
Columbia Drlg Co	2	gas	600	Natl 75	—	11,500
Continental Marine Expl Co	2	gas-btne	2120	Wlsn Titan	1340	15,000
Bge 11	dsl		975	"Oilwell" 96	975	14,500
Meadows & Walker Drlg Co	4	gas-btne	1455	"Oilwell" 76	1005	12,000
Meredith & Co	1	gas-gaso-btne	—	Emsco G-500	680	9,500
	4	gas-gaso-btne	—	Brwstr N-75	850	11,500
Cherokee County						
Gibson Drlg Co	1	gas-btne	275	Wlsn Mogul 42	265	5,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Childress County						
Jack Grace Drlg Co	17	gas-btne	370	Wlsn Giant	700	8,000
Clay County						
Clyde Gibson Drlg Co	1	gas	600	Wlsn Gnt Rdair	700	7,000
H O Grace Drlg Co	4	btne	—	—	—	7,500
W B Omohundro	4	btne	450	Wlsn Atlas	—	6,000
Cochran County						
Hissom Drlg Co	3	gas	450	Beth S-60	450	6,500
Fred Pool Drlg Co	1	gas	580	M-CSCO U-15	600	7,500
Western Drlg Co Inc	13	dsl	600	Crdwll O	325	9,000
	16	dsl	600	Emsco 350	290	6,000
	17	btne	440	Crdwll L	145	4,000
Coke County						
Dual Drlg Co	2	gas	400	Wlsn Gnt	400	7,500
Gardner Bros Drlg Co Inc	8	gas-btne	500	Natl 50	675	7,000
Roy Guffey Drlg Co	2	gas-btne	628	M-CSCO U-15	628	7,500
Tucker Drlg Co	3	gas	600	Ideco TC-600	—	9,500
Coleman County						
Tex-Mex Drlg Co	9	gas	400	Emsco 250	450	5,500
Cooke County						
Brown & Martin Drlg Co	1	btne	230	Wlsn Gnt	215	5,500
	2	btne	150	Wilson	105	1,500
Felderhoff Bros Drlg Co	1	gas	165	Wlsn Mogul	185	4,700
Roy Guffey Drlg Co	5	gas-btne	430	M-CSCO U-34	260	5,500
Gene McCutchin Drlg Co	8	gas	550	Natl 50	550	8,000
Trachta Drlg Co	1	dsl	250	Wilson	185	3,000
Crane County						
Gardner Bros Drlg Co Inc	6	gas-btne	500	Natl 75	700	10,500
	11	gas-btne	750	Natl 100	1050	12,500
	20	gas-btne	275	Natl T-25	350	4,000
Guadalupe Drlg Co	1	gas-btne	700	Ideco M 1000	—	10,000
Helmerich & Payne Inc	42	gas	970	Natl 100	1000	13,000
Johnn Drlg Co	7	gas	375	Brwstr N-45	400	7,000
	9	gas	375	Brwstr N-45	400	7,000
Keating Drlg Co	6	gas-gaso	—	—	450	5,000
Layton & Newell Drlg Co	1	gas-btne	500	M-CSCO U-15	600	8,000
	2	gas-btne	450	Natl 75	780	12,000
McQueen & Stout Drlg Co	21	LPG	—	Emsco GA-500-53	—	—
B B Smith Inc	1	gas	600	Brwstr N-4	300	6,000/3½"
	2	gas	600	M-CSCO U-15	450	7,000
	3	gas	400	Beth S-45	200	6,000/3½"
Western Serv Drlg Co Inc	1	gas-btne	340	Natl 50	360	5,000
Carl J Westlund Inc	7	gas-btne	650	Wlsn Rdair	—	8,500
Crockett County						
Bolin Oil Co & D H Bolin	1	gas	225	Natl T-12	145	3,500
Johnn Drlg Co	5	gas	375	M-CSCO U-15	600	8,500
Culberson County						
Lowe Drlg Co	9	gas	2000	Natl 125	2000	17,000
McQueen & Stout Drlg Co	9	LPG	225	Crdwll RL	185	4,500
Dawson County						
Cactus Drlg Corp of Tex	6	gas-btne	300	M-CSCO U-15	—	8,500
Empire Drlg Co	7	gas	600	Wlsn Titan	975	13,500
J E Jones Drlg Co	3	gas	700	"Oilwell" 76	855	12,000
Keating Drlg Co	8	gas-gaso	—	—	650	8,500
Milhoan Drlg Co	7	gas	600	"Oilwell" 76	—	8,000
Dale Mount Drlg Inc	101	gas	850	Emsco	570	9,000
Parker Drlg Co	28	gas	—	Natl 50	700	9,000
De Witt County						
Appell Petroleum Corp	2	dsl	520	Frnks SG-101	400	8,500
Boyd & Durst Drlg Contr	2	gas-btne	650	Wlsn Gnt	700	8,500
Holmes Drlg Co	6	gas-gaso	—	Beth MC-450	700	10,000
Dimmit County						
Allen & Morris	7	dsl	500	Natl 75	900	10,000/5"
Sutton Drlg Co	1	dsl	—	—	225	3,500
	7	dsl	121	Alamo	225	5,000/2⅛"
Duval County						
Harkins & Co	4	gas-gaso	700	Wlsn Gnt	700	9,500
Eastland County						
Woodson Prod Co	4	dsl	600	Mayhew 5000	270	5,500/4"
Ector County						
Big West Drlg Co	17	gas-btne	600	Wlsn Titan	900	13,000
Forest Blackstock Inc	1	gas	450	Emsco GB-350	450	8,000
Brantly Drlg Co Inc	2	gas	975	Emsco 800	1000	14,000
	4	gas	375	Beth S-55	480	6,500
	6	gas	400	Natl 50	750	9,000
Cactus Drlg Corp of Tex	2	gas-btne	300	Brwstr N-4	460	5,000
Coroco Drlg Co	1	gas-gaso	500	Beth 650	650	12,500
	4	gas-gaso	650	Wlsn Spr Titan	900	15,000
Danforth Drlg Co	1	dsl	240	Ideco H-30	350	5,000
M J Delaney Co	30	gas-btne	500	Beth 1013	1200	15,000
Dillard-Waltermire Inc	16	gas	500	Natl 50	700	6,500
	12	gas	600	Wlsn Gnt	800	8,000
	14	gas	600	Wlsn Gnt	800	8,000

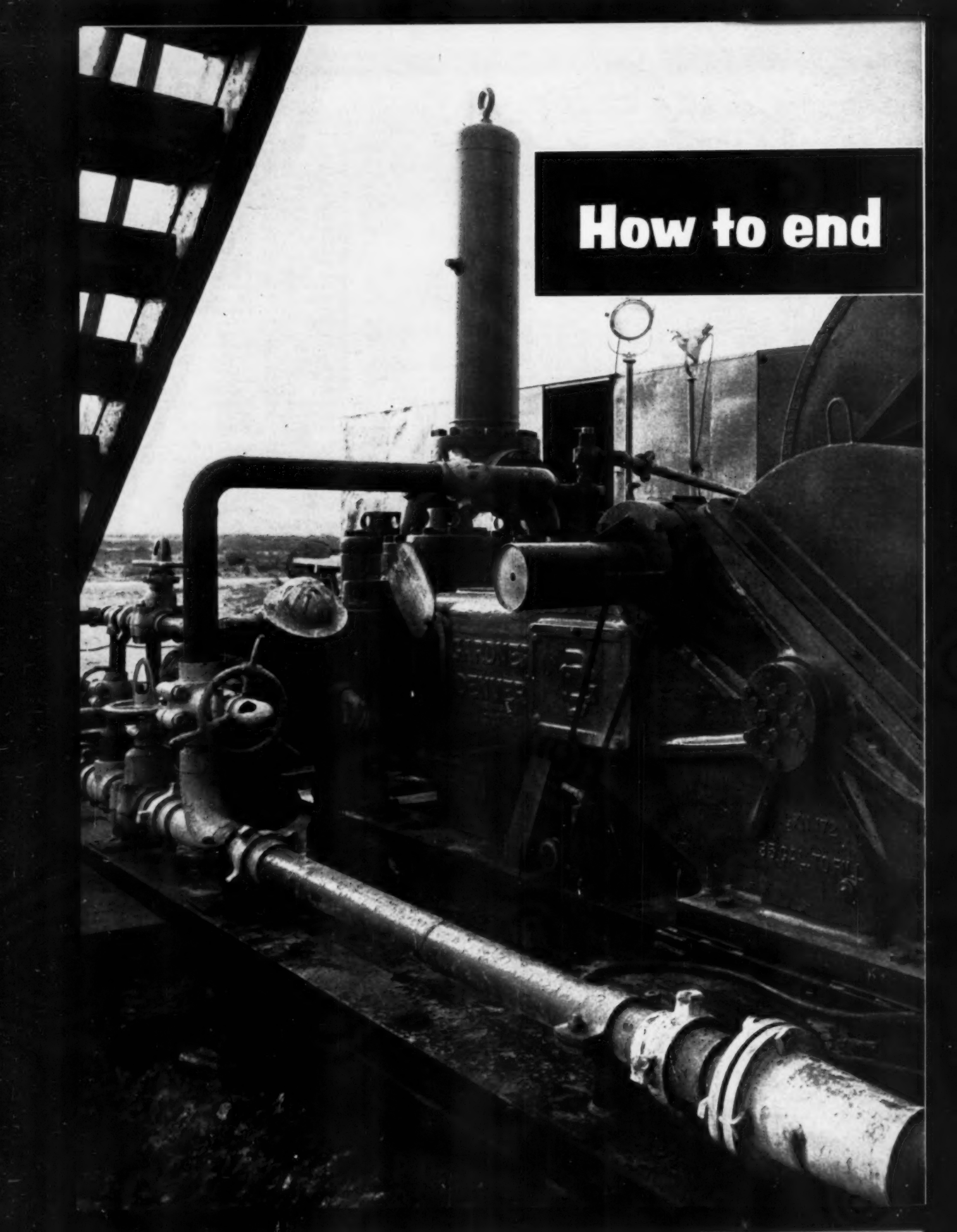
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Eastland Drlg Co	1	gas	—	—	750	10,000
	2	gas	—	—	540	7,500
	4	gas	—	—	190	4,500
Gardner Bros Drlg Co Inc	15	gas-btne	1000	"Oilwell" 96	1500	16,000
	18	gas-btne	400	Natl 50	575	7,000
Johnn Drlg Co	4	gas	375	M-CSCO U-15	600	8,500
J E Jones Drlg Co	1	gas	500	"Oilwell" 66	630	8,000
Layton & Newell Drlg Co	3	gas-btne	500	Natl 75	820	12,000
Lee Drlg Co	5	gas-gaso	1050	Natl 100	—	13,000
	7	gas-gaso	440	Beth S-55	—	6,000
Lowe Drlg Co	7	gas	750	Wilson	750	10,000
McQueen & Stout Drlg Co	10	LPG	225	Crdwll RL	185	4,500
	12	LPG	225	Crdwll RL	185	4,500
Parker Drlg Co	26	gas-elec	—	Natl 130	2000	20,000
	32	gas	—	Natl 50	700	9,000
Robinson Bros Drlg Co	1	gas	800	Brwstr N-75	800	10,000
	3	gas	300	Brwstr N-55	500	6,500
Western Drlg Co Inc	18	btne	450	Crdwll O	225	8,000
Western Serv Drlg Co Inc	7	gas-btne	600	Natl 50	700	7,000
Fayette County						
Columbia Drlg Co	6	dsl	800	Emsco GA-500	520	11,000
Hamman Oil & Ref Co	7	dsl	340	Brwstr N-75	600	11,000
Fisher County						
Roy Guffey Drlg Co	6	gas-btne	628	M-CSCO U-15	628	7,500
West Central Drlg Co	7	gaso-btne	225	Wlsn Gnt	250	5,000
Fort Bend County						
Big "6" Drlg Co	2	dsl	550	M-CSCO U-15	550	10,000
Freestone County						
M J Delaney Co	24	gas-btne	500	Beth M-58	600	9,500
	31	gas-btne	450	Wlsn Gnt Rdair	650	7,000
Delta Drlg Co	42	dsl	600	M-CSCO U-15	550	8,500
W W Wise Drlg Inc	1	gas	400	M-CSCO U-15	400	8,000
Gaines County						
Coroco Drlg Co	6	gas-gaso	400	"Oilwell" 66	500	9,000
M J Delaney Co	19	gas-btne	600	Emsco J-1250	1200	15,000
Dual Drlg Co	1	gas	600	Wlsn Gnt	600	9,000
	4	gas	600	Beth 450	1100	13,000
O E Hall Drlg Co	3	gas	320	M-CSCO U-15	700	8,000
	5	gas	700	M-CSCO U-40	1210	12,000
Johnn Drlg Co	3	gas	650	Wlsn Atlas	900	10,000
Moran Oil Prod & Drlg Corp	3	gas	950	M-CSCO U-15	800	8,500
Dale Mount Drlg Inc	112	gas	1200	Emsco	1200	12,000
B L McFarland Inc	10	gas	500	Brwstr N-55	575	8,000
Davey O'Brien Drlg Co Inc	3	gas-btne	700	Emsco GB-500	700	9,000
Robinson Bros Drlg Co	2	gas	800	Brwstr N-75	800	10,000
Texas R F O Inc	4	gas	675	M-CSCO U-15	675	8,500
Galveston County						
Continental Marine Expl Co	Bge 12	dsl	2000	Wlsn Titan 66	1875	22,800
Hunt Drlg Co Inc	7	stm	1200+	Emsco ECA	1200+	16,000
Meadows & Walker Drlg Co	2	pwr	1950	Beth 1500	1578	16,000
Howard Parker Co	1	gas-btne	600	Crdwll D	500	8,000
The Power Rig Drlg Co	Bge 6	gas-btne	800	Emsco GB-500	—	11,000
	Bge 7	dsl	1200	Emsco GB-800	—	15,000
Garza County						
Cactus Drlg Corp of Tex	10	gas-btne	700	Beth M-58	700	9,000
Dillard-Waltermire Inc	10	gas	600	Wlsn Gnt	800	8,000
Dual Drlg Co	3	gas	600	Beth M-58	600	10,000
	5	gas	400	Emsco GA-500	400	7,000
Empire Drlg Co	8	gas	500	M-CSCO U-15	675	8,500
St John Drlg Co	1	gas	400	Wlsn Gnt Rdair	700	8,500
Texas R F O Inc	1	gas	325	Beth S-60	360	8,000
	3	dsl-gas	250	Emsco GA-250	290	5,000
Western Drlg Co Inc	6	dsl	600	—	290	6,000
	11	dsl	288	Emsco 350	375	6,500
Wes-Tex Drlg Co	6	btne	500	M-CSCO U-15	640	8,500
Glasscock County						
Carl B King Drlg Co of Tex	12	gas-gaso	1000	Natl 75	1000	12,500
Goliad County						
Harkins & Co	1	gas-gaso	555	M-CSCO U-15	555	9,500
	2	dsl	300	Wlsn Gnt	300	6,500
Gonzales County						
Adkins Drlg Co	1	gas-gaso	1125	Crdwll O	825	10,000
Gray County						
Cree Drlg Co Inc	2	gas-btne	255	M-CSCO U-10	360	4,500
King Edwards (Edwards Drlg Co)	11	btne	—	Wlkr-Nr Spdr	—	—
Murphy & McKernan	1	dsl	390	M-CSCO U-15	375	7,500
Wagner & Wyant Drlg Co Inc	3	dsl	300	M-CSCO U-34	300	5,000
Grayson County						
Falcon Seaboard Drlg Co	33	gas	1050	Beth 1013	1350	16,000
Jack Grace Drlg Co	12	gas-btne	625	Wlsn Atlas	1200	10,000
Tibbits Drlg Co	2	gas	350	Wlsn Gnt	425	7,000
Gregg County						
Delta Drlg Co	7	stm	750	Emsco UB-54	1200	12,000
	15	gas-btne	530	M-CSCO U-15	600	8,000
Gibson Drlg Co	4	gas-btne	226	Wlsn Mogul	225	4,500
Iran Drlg Corp	1	gas	300	Wlsn Gnt	500	8,000
Tex-Mex Drlg Co	6	gas-btne	1200	Wlsn Titan	1200	13,000
Hansford County						
Arrow Drlg Co	1	gas	860	Ideco 1000	—	11,500
	9	gas	560	Emsco 500	—	8,000
	10	gas	560	Emsco 500	—	8,000
Cree Drlg Co Inc	4	gas-btne	350	Emsco GA-500	600	9,000
Drlg & Expl Co of Del Inc	35	gas-gaso	1200	Emsco GB-800	900	12,000
Moran Bros Inc	6	gas	900	Wlsn Gnt	750	9,500
Davey O'Brien Drlg Co Inc	2	gas-btne	840	Emsco GA-500	840	9,000
Wagner & Wyant Drlg Co Inc	2	dsl	500	M-CSCO U-15	675	8,000
Tommy Ward Drlg Co	3	gas	350	Brwstr N-35	650	5,000
Hardeman County						
Dillard-Waltermire Inc	11	gas	600	Wlsn Gnt	800	8,000
Hardin County						
Falcon Seaboard Drlg Co	18	dsl	800	Whind B-85	975	11,000
Owen Drlg Co	8	dsl	1040	Natl 50	1040	10,000
Carnes W Weaver Drlg Co	1	gas-btne	700	"Oilwell"	—	10,500
Harris County						
Brewster-Bartle Drlg Co Inc	4	gas	—	"Oilwell" 76	—	11,000
Comet Drlg Co	3	stm	900	Ideco Jr Gnt	—	10,000
Howard Parker Co	6	gas-btne	400	Crdwll D	500	8,000
Carnes W Weaver Drlg Co	5	gas-btne	465	M-CSCO U-34	—	5,000
W L B Drlg Co	1	gas-gaso-btne	370	Brwstr N-35	196	3,500
Harrison County						
Crow Drlg & Prod Co	17	dsl	650	Brwstr CR-48T	650	7,500
Penrod Drlg Co	7	dsl	665	Brwstr N-7	700	10,000
Haskell County						
E W Moran Drlg Co	3	dsl	285	Wlsn Gnt	650	7,500
W B Omohundro	8	btne	700	Wlsn Rdair	—	8,000
Hemphill County						
Keating Drlg Co	11	gas-gaso	—	—	650	8,500
	18	gas-gaso	—	—	1150	14,000
Lynn Drlg Co	5	gas-btne	725	Natl 75	900	10,500
Rowan Drlg Co Inc	2	gas-btne	840	Natl 75	1120	11,000
Henderson County						
Halbert Drlg Co	2	gas-btne	285	Wlsn Rdair	445	6,500
Travis Ward Drlg Co	3	gas-LPG	2000	Wlsn Spr Titan	1400	16,000
Hidalgo County						
Frio Drlg Inc	3	gas-btne	800	Brwstr N-55	800	10,500
Holmes Drlg Co	3	gas-gaso	—	Natl 110	1500	16,000
	7	gas-gaso	—	Beth MC-450	1000	11,000
J & C Drlg Co	5	dsl	800	Wlsn 54	800	12,000
Milam Drlg Co	1	gas-btne	600	Emsco G-500	600	8,000
Viking Drlg Co	1	dsl	475	Natl 50	500	8,500
	2	dsl	475	Natl 50-A	500	8,500
	3	gas-gaso	800	M-CSCO U-15	600	9,000
Hockley County						
Drlg & Expl Co of Del Inc	14	gas-elec	1100	Natl 34-10	1000	17,000
Hopkins County						
Maxwell Herring Drlg Corp	4	gas	800	Wlsn Gnt Rdair	800	10,500
Houston County						
Travis Ward Drlg Co	2	dsl	1550	Wlsn Titan	1100	12,500
Howard County						
Forest Blackstock Inc	3	gas	650	Emsco 500	650	9,000
Brantly Drlg Co Inc	7	gas	975	Beth 450	1125	12,500
Hutchinson County						
Brown & Thorp Drlg Co	14	LPG	150	Natl T-12	145	3,500
Canadian River Drlg Co	1	dsl	300	M-CSCO U-34	300	6,000
	2	dsl	440	Wlsn Mogul	250	3,000
Dillard-Waltermire Inc	15	gas	800	Wlsn Atlas	1200	11,000
Drlg & Expl Co of Del Inc	24	gas	225	Wgnr Mrhse	400	5,000
	25	gas	225	Frnks 137/33 DTDX	400	5,000
Jack Grace Drlg Co	16	gas-btne	1020	Wlsn Titan	1200	12,500
J R McGill	1	gas-gaso	570	Emsco	570	7,000
Schafer Drlg Co	1	gas-gaso	1200	M-CSCO U-40	900	12,000
	3	gas-gaso	400	M-CSCO U-15	600	10,000
	7	gas-gaso	200	Ideco H-35	200	5,000
Jack County						
Anderson Drlg Co	1	btne	225	Wlsn Mogul	—	4,000
Bolin Oil Co & D H Bolin	6	gas	350	Wlsn Gnt Rdair	250	6,500
	9	gas	185	Wlsn Super	145	4,000
Jess P Cross Drlg Contr	1	gas-btne	250	Wlsn Mogul	230	4,500/3½"
H O Grace Drlg Co	1	btne	—	—	—	6,000
Graytex Drlg Co	1	gas	325	Natl T-32	400	6,500
	8	gas	325	Wlsn Mogul	300	4,000
Leatherwood Drlg Co	5	gas	220	Wlsn Gt Rdair	—	6,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
E W Moran Drlg Co	5	gas	370	Natl 50	650	7,500
Ward Drlg Co	2	btne	300	Wlsn Gnt	600	5,000
Jackson County						
Gilmour Drlg Co	3	gas	500	Wlsn Gnt	300	6,000
Mac Drlg Co	5	gas-gaso-btne	275	Beth S-45	450	7,500
	7	stm	500	Natl 34-26	5000	10,000
Jasper County						
Steen Drlg Co	3	btne-gas	700	Emsco J-750	1000	11,500
Jefferson County						
Clegg & Hunt	2	stm	—	Emsco H-54	—	11,000
	10	btne-gas	—	Natl 50-A	—	10,000
Meredith & Co	3	gas-gaso-btne	—	"Oilwell" 96	1150	13,000
Howard Parker Co	3	gas-btne	500	Crdwll O	900	11,000
Jeff Davis County						
Penrod Drlg Co	6	dsl	2000	Natl 110	1200	16,000
Jim Hogg County						
Appell Petroleum Corp	4	gas-gaso	315	Wlsn Mogul	175	4,000
Well Drillers Inc	2	gas-gaso-btne	1821	Ideco 7-11 Spr	1446	14,000
Jim Wells County						
Appell Petroleum Corp	3	gas-gaso	510	Brwstr N-4	225	6,000
Chiles Drlg Co	1	dsl	600	Brwstr N-7	600	8,500
Gilmour Drlg Co	1	gas	800	M-CSCO U-15	600	8,500
Hunt Drlg Co Inc	3	gas	965	Emsco GB-350	480	8,500
Jones County						
Black Drlg Co	1	dsl	275	Frnks	250	4,000/3½"
Drillers Inc	U-15	dsl	—	M-CSCO U-15	600	7,200
Johnson-Gadbois Drlg Co	5	gas	410	Wlsn Mogul	—	4,000
W B Omohundro	10	btne	300	Brwstr N-3	—	4,500/3½"
H F Pettigrew Drlg Co	1	—	—	Mayhew Prtble	—	—
Wes-Tex Drlg Co	7	btne	200	Crdwll D	225	3,000
Karnes County						
Davis & Bates Inc	1	dsl	375	Brwstr N-4	350	7,000
Kaufman County						
Halbert Drlg Co	1	gas-btne	255	Wlsn Torcair	285	5,500
Kenedy County						
Del Mar Drlg Co	1	stm	800+	Alco BIW 12	1000	11,000
Kent County						
Empire Drlg Co	2	gas	500	Brwstr N-7	750	9,500
	5	gas	325	M-CSCO U-15	550	8,000
General Geophysical Co	32	btne	—	—	500	7,500
John Grappe Drlg Co	2	gas-btne	720	Beth	—	13,000
Kleberg County						
Hunt Drlg Co Inc	1	gas	1212	Brwstr N-7	732	10,000
Knox County						
Bolin Oil Co & D H Bolin	3	gas	350	Wlsn Gnt	225	5,000
La Salle County						
Buzzini Drlg Co	7	gas-btne	1150	Wlsn Atlas	930	11,000
Longhorn Drlg Corp	5	gas-btne	450	M-CSCO U-15	675	9,000
Lavaca County						
Dillard-Waltermire Inc	7	stm	800	Natl 23-9FM	1000	12,000
Liberty County						
Continental Marine Expl Co	5	gas-btne	1480	Wlsn Titan	700	12,000
Miller Bros & Bowling	2	gas-btne	800	Emsco G-450	—	8,500
Timberland Expl Co	3	gas-btne	800	M-CSCO U-15	700	9,000
Limestone County						
Walters Drlg Co Inc	5	gas	150	Mayhew 1000	150	600/2⅛"
	14	gas	—	Mayhew 1000	150	400/2⅛"
Lipscomb County						
Cree Drlg Co Inc	1	gas-btne	500	M-CSCO U-15	750	8,500
	5	gas-btne	825	M-CSCO U-40	975	14,000
Moran Bros Inc	4	gas	1000	Wlsn Titan	1200	14,000
	15	gas	1400	"Oilwell" 860	1250	17,000
Live Oak County						
J & C Drlg Co	3	gas-btne	450	Natl 50	450	7,500
Kirkwood Drlg Co	11	dsl	900	Brwstr N-7	900	11,500
Loving County						
Tom Brown Drlg Co	4	gas-btne	500	M-CSCO U-15	500	7,500
Cree Drlg Co Inc	8	gas-btne	185	M-CSCO U-34	300	4,500
Ellis	4	dsl	300	M-CSCO U-34	300	5,000
Leatherwood Drlg Co	1	gas	600	Ideco 750	—	10,000
	2	gas	400	Natl T-32	—	7,000
Lubbock County						
Sharp Drlg Co	44	dsl	1000	Beth S-45	300	5,000
Western Drlg Co Inc	14	dsl	375	Emsco 500	375	8,000
Lynn County						
Tibbits Drlg Co	5	gas	350	Wlsn Gnt	560	7,500
Madison County						
Meadows & Walker Drlg Co	3	gas-btne	900	M-CSCO U-15	675	8,500
Marion County						
Gibson Drlg Co	3	gas-btne	300	Wlsn Gnt	275	6,000
Iran Drlg Corp	2	gas	350	Wlsn Gnt	300	7,500
	3	gas	250	Crdwll RL	185	5,000
Tex-Mex Drlg Co	10	gas	—	Emsco GB-500	—	9,000
Martin County						
Coroco Drlg Co	2	gas-gaso	650	"Oilwell" 96	900	15,000
Davidson Drlg Co Inc	A	gas-btne	1000	Emsco J-1250	1000	14,000
B L McFarland Inc	11	gas	1000	Natl 100	1050	13,000
Rowan Drlg Co Inc	25	gas-btne	1260	Natl 100	1680	14,000
Tri-Service Drlg Co	8	gas	900	"Oilwell" 76	900	10,000
Matagorda County						
Harry T Bryant Drlg Co Ltd	4	gas-btne	900	Natl 75	900	12,000
Columbia Drlg Co	5	dsl	400	M-CSCO U-15	—	8,500
Hamman Oil & Ref Co	6	dsl	250	Brwstr N-4	310	6,500
Holmes Drlg Co	1	gas-gaso	—	Beth ML-450	1000	11,000
Neal Drlg Co	1	gas	750	Emsco G-500	560	10,000
McMullen County						
Allen & Morris	8	stm	500	Emsco UBLS-54	1200	12,500/5"
Del Mar Drlg Co	6	gas-btne	—	Wlsn Gnt	750	9,500
Midland County						
Henry Black Drlg Co Inc	2	gas	550	Natl 75	650	10,000
	8	gas	400	Natl 50-A	500	9,000
Forest Blackstock Inc	4	gas	570	Emsco GB-350	570	8,000
Helmerich & Payne Inc	9	gas	1200	"Oilwell" 96	1100	14,000
	43	gas	900	"Oilwell" 76	1100	11,000
Parker Drlg Co	16	gas	—	Natl 100	1400	14,000
	39	gas	—	Natl 100	1400	14,000
Sharp Drlg Co	37	gas	900	Beth MC-450	900	12,000
A W Thompson Inc	10	gas	600	Clark Pr-1000	1050	13,500
Carl J Westlund Inc	6	gas-btne	975	Wlsn Titan	—	12,000
Mitchell County						
Hack Drlg Co	2	btne	—	Crdwll S	161	4,500
Montague County						
Berry Drlg Co	1	dsl	350	Wlsn Giant	500	6,500
Holliman Drlg Co	6	gas	750	Wlsn Atlas	950	10,000
Gene McCutchin Drlg Co	5	gas	275	Wlsn Giant	275	6,500
W B Omohundro	9	btne	550	Wlsn Rdair	—	6,500
Orm Drlg Co	1	dsl	600	M-CSCO U-15	—	9,500
Pan-Tex Drlg Co	1	gas	350	Brwstr N-45	400	6,500
Dwight M Ross Drlg Co	6	gas	750	Wlsn Atlas	750	7,000
C J Simpson Drlg Co	4	gas-btne	—	Natl T-20	275	5,000
Montgomery County						
Harry T Bryant Drlg Co Ltd	5	gas-btne	700	Beth M-58	800	11,000
Mobile Drlg & Well Serv Co Inc	1	gas-btne	490	Ideco HD-35	440	7,300/3½"
Moore County						
Holt Bros Drlg Co	2	dsl	330	Ideco H-20	330	4,000
Kerr-McGee Oil Ind Inc	34	dsl	330	Frnks LTX-5000	300	5,000
Davey O'Brien Drlg Co Inc	5	gas-btne	560	Wlsn Gnt	560	8,000
Newton County						
Harry T Bryant Drlg Co Ltd	2	gas-btne	700	—	600	8,000
Timberland Expl Co	1	gas-btne	850	"Oilwell" 76	1050	10,500
Carnes W Weaver Drlg Co	6	gas-btne	540	Brwstr N-7	—	8,500
Nolan County						
General Geophysical Co	31	dsl	—	—	500	7,500
Roy Guffey Drlg Co	3	gas-btne	430	M-CSCO U-34	260	5,500
Robinson Drlg Co (Colo City)	1	btne	550	M-CSCO U-15	550	9,000/3½"
Sojourner Drlg Corp	3	dsl	550	M-CSCO U-15	—	7,500
West Central Drlg Co	5	gaso-btne	325	M-CSCO U-15	600	7,500
Nueces County						
Layton Brown Drlg Co	Bge 2	dsl	—	—	800	10,000
Chiles Drlg Co	3	dsl	400	Ideco H-40-D	460	7,500
Frio Drlg Inc	2	dsl	400	M-CSCO U-15	400	6,500
Ochiltree County						
Arrow Drlg Co	11	dsl	595	Emsco 500	—	8,000
	22	dsl	1200	Emsco 1000	—	14,000
Cree Drlg Co Inc	9	gas-btne	350	M-CSCO U-15	650	8,500
Foree Drlg Co	4	gas-btne	345	Emsco GA-500	500	7,500
Graham-Michaelis Drlg Co	2	dsl	500	M-CSCO U-15	500	7,000
	10	dsl	600	M-CSCO U-15	600	9,000
Lynn Drlg Co	3	gas-btne	1000	Natl 75	1000	11,500
Midwestern Drillers Inc	8	dsl	370	M-CSCO U-15	750	8,500
Rowan Drlg Co Inc	10	gas-btne	1020	Beth 450	766	9,000
Rip C Underwood	1	gas-LPG	660	M-CSCO U-15	660	9,500
Oldham County						
Cree Drlg Co Inc	3	gas-btne	225	Wlsn Giant	300	5,000
Helmerich & Payne Inc	7	gas	500	Emsco GB-500-82	700	9,000
Orange County						
Big "6" Drlg Co	5	gas-btne	500	Wlsn Gnt	500	9,000
Palo Pinto County						
Sojourner Drlg Corp	2	dsl	320	M-CSCO U-15	—	5,000
	4	btne	225	M-CSCO U-34	—	4,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Pecos County						
Alan Drlg Co	3	gas	275	Wlsn Mogul	145	3,500
Brantly Drlg Co Inc	1	gas	365	Emsco 500	500	9,000
Brown & Thorp Drlg Co	12	LPG	289	Natl T-20	290	6,000
Delta Drlg Co	2	gas-btne	400	Natl 50	450	7,000
	3	gas-btne	900	Natl 100	800	12,000
	4	gas-btne	800	Natl 100	800	12,000
	36	gas-btne	900	Wlsn Titan	900	15,000
Helmerich & Payne Inc	37	gas	1200	"Oilwell" 96	1450	15,000
Parker Drlg Co	44	gas	—	Natl 125	1400	15,000
Penrod Drlg Co	32	dsl	1500	Brwstr N-12	1675	18,000
Rowan Drlg Co Inc	9	gas-btne	900	Natl 75	1110	11,000
	29	gas-btne	1200	Natl 100	1480	14,000
A W Thompson Inc	4	gas	650	Beth 810	1050	13,500
Warton Drlg Co	3	gas	1620	Natl 110	1600	14,000
Reagan County						
Tri-Service Drlg Co	2	gas	675	"Oilwell" 66	675	8,500
Wilbanks & Rutter Drlg Co	1	gas	1050	M-CSCO U-40	1050	10,000
Reeves County						
Tom Brown Drlg Co	2	gas-btne	325	Natl T-12	280	4,500
Falcon Seaboard Drlg Co	Z-11	gas-btne	1000	Beth 950	1020	16,000
Leatherwood Drlg Co	3	dsl	220	Natl T-20	—	6,000
Refugio County						
J & C Drlg Co	2	stm	600+	Emsco H-46	700+	9,000
	6	gas-btne	450	Natl 50	450	7,500
	7	gas-btne	700	Emsco 500	600	9,000
Viking Drlg Co	4	gas-gaso	980	Ideco M 10,000	750	12,000
Roberts County						
Parker Drlg Co	57	gas	—	Natl FE 23-X10	1800	18,000
Wagner & Wyant Drlg Co Inc	1	dsl	300	M-CSCO U-15	675	8,000
Runnels County						
Burger Drlg Co	1	gas	325	Wlsn Mogul	185	4,000
Frank Caraway Drlg Co	1	btne-gas	225	Beth S-50	—	5,000
Cooper Drlg Co	1	gas-btne	450	Natl 50	450	6,500
Herb Expl Co	3	btne	—	Failing 1500	—	2,000/2⅛"
Johnson-Gadbois Drlg Co	2	gas	400	Wilson	—	6,500
Robinson Drlg Co	4	btne-gas	155	Crdwll S	140	4,500/3½"
St John Drlg Co	2	gas	300	Natl 50	450	7,000
Wes-Tex Drlg Co	3	btne	225	Crdwll 53	420	5,500
Rusk County						
Robert M Bass Drlg Contr	4	gas-LPG	350	Brwstr N-45	350	7,800
	5	gas-LPG	300	Wlsn Giant	300	5,500
Milton Crow Inc	5	gas	780	Brwstr N-7	520	7,500
Gibson Drlg Co	2	gas-btne	226	Wlsn Mogul 42	145	5,000
San Patricio County						
Allen & Morris	2	stm	400	Alco BIW 11	600	12,000/5"
Harkins & Co	6	gas-gaso	675	M-CSCO U-15	675	9,500
Miller Bros & Bowling	1	gas-btne	495	Emsco G-300	—	5,500
Schleicher County						
Davidson Drlg Co Inc	D	btne	315	Wlsn Mogul	600	7,500
Fortune Drlg Corp	1	gas	325	Beth S-55C	524	7,500
Fryer & Hanson Drlg Co	4	gas-btne	1150	"Oilwell" 76	1200	12,000
Tucker Drlg Co	5	gas	620	Crdwll O	620	9,500
Scurry County						
John Grappe Drlg Co	1	gas-btne	520	Beth	—	8,500
Dave Harlin Drlg Co	1	btne	300	Beth S-45	300	8,000/2⅛"
J E Jones Drlg Co	2	gas	500	M-CSCO U-15	663	7,500
Pico Drlg Co	3	gas-btne	610	M-CSCO U-15	470	8,500
	8	gas-btne	756	Beth M-58	925	10,500
Robinson Drlg Co (Colo. City)	2	btne	600	M-CSCO U-15	600	9,000/3½"
	3	btne	300	Beth MC-250	300	5,000/3½"
	4	btne	235	Beth S-45-E	150	4,000/3½"
St John Drlg Co	3	gas	400	Brwstr N-55	570	7,500
Thomas & Billups Drlg Co	1	btne	450	Emsco 300	450	6,000
Shelby County						
Gibson Drlg Co	5	gas-btne	275	Wlsn Giant	275	6,000
Glenn Drlg Co	2	dsl	280	M-CSCO U-15	450	8,500
Keoughan Drlg Co Inc	1	dsl	520	Crdwll O	—	8,500
Sherman County						
Cree Drlg Co Inc	6	gas-btne	255	Wlsn Giant	300	5,000
Graham-Michaelis Drlg Co	5	dsl	275	Crdwll B	275	4,000
Smith County						
Robert M Bass Drlg Contr	3	gas-LPG	400	Wlsn Gnt Rdair	600	8,500
Delta Drlg Co	22	gas-btne	530	M-CSCO U-15	600	8,000
	40	gas-btne	325	Wlsn Rdr Gnt	690	8,000
Maxwell Herring Drlg Corp	3	gas	600	Wlsn Gnt Rdair	600	9,500
	8	gas	300	Wlsn Mogul	250	4,500
La Mance Drlg Co	4	btne	1050	Wlsn Titan		13,000
Pyburn Drlg Co	1	dsl	500	Ideco M-750	750	9,000
Tex-Mex Drlg Co	7	gas		Emsco GB-350		7,500
	12	gas		M-CSCO U-15		9,000
Trant Drlg Co	3	stm	—	—	—	15,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Stephens County						
Cooper Drlg Co	2	gas-btne	600	Wlsn Gnt	600	7,500
King Edwards (Edwards Drlg Co)	2	gas-gaso	600	M-CSCO U-15	600	9,000
Ewing Drlg Co	1	btne	—	Emsco C-42	450	5,000
Red River Drlg Co	2	gas	185	Wichtex R-4	145	3,000
Tibbits Drlg Co	3	gas	350	Wlsn Gnt	560	7,500
	4	gas	350	Wlsn Gnt	525	7,500
Sterling County						
Rheay & Reynolds Drlg Co	6	gas	300	Natl 50	750	7,000
Stonewall County						
Roy Guffey Drlg Co	4	gas-btne	628	M-CSCO U-15	628	7,500
Paine Drlg Co	5	btne	450	Wlsn Giant	450	7,000
Sutton County						
Pico Drlg Co	2	gas-btne	475	Brwstr N-7	475	8,500
Pool & Gerlich Drlg Co	D-3	gas	350	Emsco G-250	300	6,000
Tucker Drlg Co	4	dsl	610	Beth J-55	—	9,500
Taylor County						
H O Grace Drlg Co	3	btne	—	—	—	6,000
Hack Drlg Co	4	btne	—	—	161	2,500
Herb Expl Co	2	btne	—	Failing 1500	—	1,750/2⅛"
Johnson-Gadbois Drlg Co	1	gas	600	M-CSCO U-15	600	8,000
Low Drlg Co	1	btne	—	Emsco	290	7,000
	2	btne	—	Wilson	145	3,000
Norman Drlg Corp	2	dsl	330	M-CSCO U-10	350	5,000
Red River Drlg Co	3	gas	185	Crdwll HL	165	4,500
Robinson Drlg Co	6	btne-gas	180	Crdwll OC	450	7,500/4"
	8	btne-gas	180	M-CSCO U-15	450	8,500
Sojourner Drlg Corp	1	btne	218	M-CSCO U-15	—	7,500
West Central Drlg Co	8	gaso-btne	325	Wlsn Roadair	975	10,000
	9	gaso-btne	225	Spencer	145	3,000
Wes-Tex Drlg Co	1	btne	250	M-CSCO U-10	650	6,000
	2	btne	200	Brwstr N-4	400	5,500
Terrell County						
Falcon Seaboard Drlg Co	Z-10	dsl	1100	Beth 950	1350	16,000
Hissom Drlg Co	6	gas	1350	Emsco A-800	1350	14,000
Johnn Drlg Co	6	gas	850	Brwstr N-95	1300	14,000
Rowan Drlg Co Inc	28	gas-btne	1300	Natl 125	1530	15,000
A W Thompson Inc	1	gas	1500	Emsco A-1500	1800	18,000
Western Serv Drlg Co Inc	2	gas-btne	600	Natl 50-A	700	8,000
Throckmorton County						
Alan Drlg Co	1	gas	550	Wlsn Giant	850	8,000
R-G Drlg Co	1	gas-gaso	—	Wilson	650	6,500
	2	gas-gaso	—	Wlsn	650	8,000
	3	gas-gaso	—	Wilson	450	6,500
	5	gas-gaso	—	Wilson	650	8,000
Schulz & Brannan Drlg Co	1	dsl	400	Wlsn Mogul	400	5,000
Tom Green County						
Tucker Drlg Co	1	gas	600	Brwstr N-55	—	9,500
	2	gas	425	Brwstr N-4	—	6,500
Tyler County						
Timberland Expl Co	2	gas-btne	1100	"Oilwell" 76	1200	12,500
Upton County						
J E Jones Drlg Co	4	gas	285	Emsco GA-250	400	5,000
Penrod Drlg Co	1	gas-btne	1300	Brwstr N-12	1750	15,000
Victoria County						
Harkins & Co	3	gas-gaso	850	M-CSCO U-15	850	10,000
Kirkwood Drlg Co	8	dsl	550	Brwstr N-4	550	9,000
Walker County						
Meadows & Walker Drlg Co	1	gas-btne	875	"Oilwell" 66	828	10,500
Ward County						
Bolin Oil & D H Bolin	7	gas	225	Beth S-50	185	4,500
Hissom Drlg Co	1	gas	600	Emsco 500	600	8,500
	2	gas	400	M-CSCO U-34	500	6,000
Keating Drlg Co	16	gas-gaso	—	—	450	6,500
La Mance Drlg Co	5	btne	550	M-CSCO U-15	550	7,500
B L McFarland Inc	4	gas	400	Crdwll RL	200	4,500
	9	gas	400	Crdwll RL	200	4,500
Pico Drlg Co	1	dsl	368	Brwstr N-4	216	5,000
Texas Drlg Co	1	gas	300	Natl T-20	300	5,000/3½"
Western Serv Drlg Co Inc	13	gas-btne	550	Beth S-45-E	350	5,000
Webb County						
Allen & Morris	4	gas	400	Natl 50	400	8,500/5"
Del Mar Drlg Co	2	dsl	400	Natl 50	762	8,000
Dillard-Waltermire Inc	2	dsl	1800	Natl 125	2400	16,000
Kirkwood Drlg Co	10	dsl	400	Wlsn Mogul	400	7,000
Longhorn Drlg Corp	4	gas-btne	450	M-CSCO U-15	675	9,000
Miller Bros & Bowling	3	gas-btne	850	Emsco GC-500	—	9,000
Wichita County						
Bolin Oil Co & D H Bolin	10	dsl	300	Wlsn Giant	300	4,500
R W Darden Drlg Co	1	gas	145	Wichtex R-3	140	3,000
Jim Fish Drlg Co	1	gas	225	Wilson	140	4,500
T V Gorman Drlg Contr	1	dsl	200	Wichtex R-3	200	3,000
Gray Drlg Co	1	gas-gaso	220	Wlsn Gnt Rdair	450	5,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Harvey Drlg Co	3	gas-btne	350	Wisn Mogul	400	5,000
	5	gas-btne	750	Wisn Giant	800	8,500
	6	gas-btne	500	Wisn Giant	500	7,500
Hull Oil Co	1	btne	140	Wikr-Nr R-2	—	2,150
L & H Drlg Co	—	btne-gas	155	Crdwll EC	155	6,000/3½"
Wilbarger County						
T V Gorman Drlg Contr	2	dsl	300	Wisn 38 Torcair	300	4,500
Graytex Drlg Co	2	gas	325	Natl T-12	325	4,500
B M Hester	1	btne	325	Natl T-20	200	6,000
E W Moran Drlg Co	6	gas	225	Wisn Mogul	160	4,500
R Benton Ross Inc	1	dsl	225	Wilson	165	4,000
Winkler County						
Big West Drlg Co	11	gas-btne	500	M-CSCO U-20	900	14,000
Bolin Oil Co & D H Bolin	2	gas	225	Natl T-12	185	4,500
Tom Brown Drlg Co	3	gas-btne	325	Wisn Gnt	265	5,000
Camden Drlg Co	1	dsl	300	Natl T-20	300	5,000
Gardner Bros Drlg Co Inc	12	gas-btne	750	Natl 100	1050	12,500
King-Phillips Inc	3	dsl	622	Ideco H-40D	—	5,500/4"
Leatherwood Drlg Co	4	gas	450	Crdwll	450	6,000
Milhoan Drlg Co	3	gas	900	Beth 450	—	10,000
Dale Mount Drlg Inc	111	gas	1200	Emsco	1200	14,000
Parker Drlg Co	33	gas	—	Natl 75	1000	11,000
	52	gas	—	"Oilwell" 76	1400	12,500
Pool & Gerlich Drlg Co	D-1	gas	260	M-CSCO U-34	300	5,000
Sharp Drlg Co	32	gas	1200	Beth MC-450	1200	12,000
	36	gas	1350	Beth MC-950	1350	15,000
	43	gas	2000	Beth 1013	2000	20,000
A W Thompson Inc	11	gas	650	Beth 450	1050	13,500
Western Serv Drlg Co Inc	12	dsl	250	Natl T-20	520	4,000
Wes-Tex Drlg Co	5	btne	550	Natl 50	550	7,500
Wise County						
Akin & Dimock	2	dsl	300	Beth S-55	420	7,000
Bolin Oil Co & D H Bolin	4	gas	350	Wisn Gnt	500	7,500
Garvey Drlg Co	20	dsl	300	Wisn Mogul 42	450	7,000
Jack Grace Drlg Co	8	gas-btne	625	Wisn Atlas	1200	10,000
John W Harris Drlg Co	1	gas	500	Hou Prtble	450	6,500
	2	gas	500	Emsco GC-500	500	8,000
John Haseman Inc	1	gas-btne	350	Ideco H-35D	300	6,000
	2	gas-btne	150	Wisn Super	150	3,500
	4	gas-btne	150	Crdwll K-200	150	3,500
Holliman Drlg Co	3	gas	255	M-CSCO U-15	600	7,500
E W Moran Drlg Co	4	gas	300	M-CSCO U-15	650	7,500
Paine Drlg Co	6	btne	500	Wisn Giant	500	7,000
Trio Drlg Co	1	gas	520	Wisn Giant	—	8,000
	2	gas	520	Natl 50	—	6,500
	3	gas	450	Wisn Gnt	—	6,500
	4	gas	450	Natl 50	—	6,500
Walters Drlg Co Inc	12	dsl	—	Mayhew 1000	300	400/2⅞"
Wood County						
Ace Drlg Co	2	gas	680	Emsco G-500	500	9,000
Robert M Bass Drlg Contr	1	gas-LPG	500	Wisn Rdair	800	10,000
M J Delaney Co	21	gas-btne	500	Wisn Titan	650	9,500
Maxwell Herring Drlg Corp	1	gas	300	Wisn Mogul	400	6,000
Yoakum County						
Brantly Drlg Co Inc	5	gas	375	Emsco 250	250	4,000
Dillard-Waltermire Inc	13	gas	800	Wisn Titan	1200	12,000
Empire Drlg Co	9	dsl	325	Wisn Giant	550	7,500
Carl B King Drlg Co of Tex	1	gas-gaso	1000	Natl 100	1000	13,500
Llano Drlg Co	4	gas	—	Natl 75	1050	12,000
Chas E Long Jr Inc	1	gas	200	Emsco G-300	400	6,000
Moran Oil Prod & Drlg Corp	1	gas	950	M-CSCO U-15	800	8,500
Fred Pool Drlg Co	3	gas	290	M-CSCO U-10	225	5,500
Sharp Drlg Co	35	gas	1500	Beth MC-950	1500	18,000
	38	gas	900	Beth M-58	900	10,000
Tri-Service Drlg Co	6	gas	1350	"Oilwell" 96	1350	16,000
Young County						
King Edwards (Edwards Drlg Co)	3	gas-gaso	600	M-CSCO U-15	600	9,000
J W Hastings Drlg Co	4	gas-btne	330	Wisn Torcair	220	5,000
	5	gas-btne	864	Wisn Gnt Rdair	864	8,200
E W Moran Drlg Co	1	gas	500	M-CSCO U-15	560	7,500
Oney Drlg Co	5	gas	250	Crdwll S	200	4,000
Paine Drlg Co	7	dsl	450	Wisn Giant	450	7,000
Louis Pitcock Drlg Co	1	gas-btne	225	Beth S-55	600	7,500
	7	gas-btne	225	Beth S-45	3250	4,000/3½"
Revier Drlg Co	2	gas-btne	600	Wisn Giant	600	7,000
Zapata County						
Allen & Morris	5	pwr	1100	"Oilwell" 76	780	12,000
Longhorn Drlg Co	6	gas-btne	500	"Oilwell" 76	1185	14,000
UTAH						
Duchesne County						
Mountain States Drlg Co Inc	4	gas-dsl	600	Emsco GB-500	—	9,000
Emery County						
Hewit-Gulick Drlg Co	3	dsl	855	Natl 50-A	900	9,000
Willard Pease Drlg Co	1	dsl	340	Stratmaster 90	320	5,500/3½"
San Juan County						
Calvert Drlg Inc	20	dsl	350	Ideco H-525	600	8,500
Camay Drlg Co Rocky Mt Div	3	dsl	560	Natl 50-A	450	8,500
Carmack Drlg Co	1	dsl	680	Natl 50-A	450	8,000
D-K Drlg Co	3	gas	500	Natl 50	500	6,500
Exploration Drlg Co	4	gas	725	M-CSCO U-15	600	8,000
	8	gas	725	M-CSCO U-15	600	8,000
	15	gas	800	Natl 75-CA	900	11,000
Kerr-McGee Oil Ind Inc	1	gas	825	M-CSCO U-15	832	10,000
R L Manning Co	4	gas-btne	600	Emsco 450	450	7,000
	12	gas-btne	650	Emsco GA-350	450	7,000
Moran Bros Inc	3	gas	550	Emsco GB-350-52	550	8,000
	7	gas	900	Wisn Gnt	750	9,500
	9	gas	700	"Oilwell" 66	750	9,500
	10	gas	600	Emsco GA-350	550	8,000
	16	gas	650	M-CSCO U-15	600	7,500
Mountain States Drlg Co Inc	6	dsl	600	Natl 50	—	7,500
R W Rine Drlg Co	2	dsl	520	Brwstr N-7	600	8,500
	6	dsl	520	Brwstr N-75	750	12,000
Rutledge Drlg Co	4	gas-btne	500	Beth C-50	675	8,000
	5	gas-btne	632	Natl 50	620	8,000
	6	gas-btne	362	Emsco 350	675	8,000
Uintah County						
A O Bullock Drlg Co	3	gas	370	Beth Twister	—	7,500
Exploration Drlg Co	11	gas	800	Beth S-60	480	8,000
Kerr-McGee Oil Ind Inc	4	gas	900	Natl 75	832	11,500
	23	gas	650	Natl 50	556	9,000
Wayne County						
Camay Drlg Co Rocky Mt Div	6	dsl	260	Johnson	450	5,000
WEST VIRGINIA						
Pocahontas County						
S W Jack Drlg Co	2	dsl	800	M-CSCO U-15	800	8,500
Union Rotary Corp	6	dsl	552	Natl 50	552	8,500
Roane County						
Eakle & Holder Drlg Co	5	dsl	600	Natl 50	600	8,500
Tucker County						
S W Jack Drlg Co	4	gas	1000	M-CSCO U-15	1000	10,000
Tyler County						
Lohmann-Johnson Oil Co Inc	9	gas	750	"Oilwell" 66	500	10,000
WYOMING						
Big Horn County						
Anschutz Oil Co Inc	7	gas	900	M-CSCO U-15	650	8,500
R L Manning Co	16	gas-btne	650	Natl T-32	450	6,000
Signal Drlg & Expl Inc	2	dsl	370	M-CSCO U-36A	420	7,500
Campbell County						
Hewit-Gulick Drlg Co	1	dsl	820	Natl 50-A	600	9,000
Carbon County						
Will I Lewis Drlg Co	5	dsl	1200	"Oilwell" 76	1200	13,500
Morrison Drlg Co Inc (Wyo)	8	dsl	210	Frnks Comet	225	5,000
Roden & McRae Drlg Co	1	dsl	625	Emsco GA-350	570	7,000
Converse County						
Big Horn Drlg Co Inc	3	gas	600	Emsco GB-250	360	6,500
Dyer Drlg Co	1	gas-gaso	325	Natl T-32	365	6,000
	2	gas-gaso	325	M-CSCO U-15	480	7,500
	4	dsl	185	Failing 66	300	3,500
J D Sprecher	2	dsl	900	Emsco J-750	900	10,500
Crook County						
Anschutz Oil Co Inc	9	gas	800	Natl 50-A	600	8,500
Delta Drlg Co	23	dsl	520	Emsco GA-500	500	8,000
Lohmann-Johnson Drlg Co Inc	4	dsl	300	M-CSCO U-15	440	5,500
Fremont County						
Anschutz Oil Co Inc	10	dsl	800	Brwstr N-55	600	8,000
Bueno Drlg Co	1	dsl	720	Natl T-20	300	5000, 6,500/3½"
Carpenter-Trant Drlg Co	5	dsl	900	Brwstr	900	12,000
R L Manning Co	10	gas-btne	1275	Emsco J-750	1125	11,000
Gabe McCall Drlg Co	2	dsl	600	Emsco GB-250	360	6,500
Rowan Drlg Co Inc	31	gas-btne	900	Natl 75	1149	11,000
Signal Drlg & Expl Inc	4	gas	300	Ideco H-25	300	4,200
Hot Springs County						
Arrow Drlg Co	14	gas	600	Wisn	—	8,000
R L Manning Co	15	dsl	540	Emsco GB-250	340	6,000
Johnson County						
A O Bullock Drlg Co	2	gas	225	Crdwll S	—	4,000
R L Manning Co	7	gas-btne	750	Emsco G-500	750	8,000
	17	gas-btne	765	Emsco GC-500	840	10,000
Roden & McRae Drlg Co	5	gas	360	Emsco GA-250 T	425	6,500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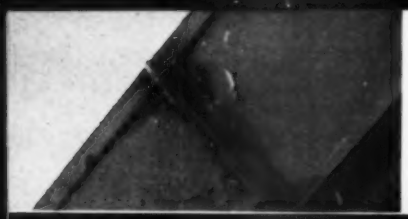


Mud-Pump Headaches

Gardner-Denver Mud Pumps have the power, the flexibility and the **dependability** to keep a well under control. They give you a real whip hand over formation pressures and circulation problems. Their reputation as **quality leaders** is unchallenged.

All parts replacements can be made in the field. The right- and left-hand cylinders in the famous **Gardner-Denver** fluid end are interchangeable. Pressure lubrication is provided in the power end. The packed oil stop head keeps oil in, mud out. One-piece connecting rods . . . no bolts to work loose. Parts are available through your nearby J&L Supply store.

Five GX models, 350, 500, 700, 1000 and 1250 h.p. Ask your local J&L Supply man for illustrated **Gardner-Denver** literature or write us at Tulsa—Drawer 2481.

Jones & Laughlin

SUPPLY DIVISION – Tulsa

If it's sold by J&L . . . .
It's the best available

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Lincoln County						
Fitzpatrick Drlg Co Inc	4	gas-btne	900	Wisn Titan Rdr	900	12,500
R L Manning Co	11	gas-btne	1080	Emsco J-1000	1305	13,000
Natrona County						
Big Horn Drlg Co Inc	1	dsl	320	Brwstr N-4	230	5,500
A O Bullock Drlg Co	1	gas	225	Wichtex R5	—	3,500
Will I Lewis Drlg Co	6	dsl	1600	M-CSCO U-20	1600	14,000
Roden & McRae Drlg Co	6	dsl	275	Frnks Rocket TD44	275	2,000
J D Sprecher	5	dsl	350	Brwstr N-45	350	6,500
Niobrara County						
Delta Drlg Co	43	dsl	400	M-CSCO U-10	450	6,000
Park County						
Carpenter-Trant Drlg Co	6	dsl	450	Wisn Giant	640	7,500
Hose-Austin Drlg Corp	4	gas	500	Emsco GB-350	588	7,500
R L Manning Co	8	dsl	550	Emsco G-500	550	7,500
Mountain States Drlg Co Inc	9	dsl-gas	1400	Natl 125	—	15,000
Roden & McRae Drlg Co	2	dsl	265	Emsco GA-300	270	4,500
	4	dsl	900	Emsco GB-800	900	12,500
Rowan Drlg Co Inc	24	gas-btne	504	Natl 50	1077	8,500
Sublette County						
Fitzpatrick Drlg Co Inc	1	gas-btne	550	M-CSCO U-15	550	8,250/4"
Kerr-McGee Oil Ind Inc	31	gas	1000	Natl 100	1680	15,000
	5	gas-btne	750	Emsco G-500	750	8,000
Mountain States Drlg Co Inc	2	gas-dsl	1000	Emsco J-750	—	10,000
	17	dsl	540	Natl T-32	—	6,000
Sweetwater County						
Camay Drlg Co Rocky Mt Div	1	gas	775	M-CSCO U-15	600	8,500
Carpenter-Trant Drlg Co	8	btne	800	Wisn Spr Gnt	1320	12,000
	9	dsl	250	Franks	300	5,000
Falcon-Seaboard Drlg Co	MA-1	gas-btne	300	M-CSCO U-35	210	6,500
	25	dsl	212	Beth S-55	212	6,500
R L Manning Co	6	gas-btne	900	Emsco GB-800	1125	11,000
Mountain States Drlg Co Inc	3	gas-dsl	600	Natl 50-A	—	7,500
Nye & Snell Drlg Co	3	gas	600	Wisn Atlas	800	11,000
Signal Drlg & Expl Inc	6	gas-btne	1000	Natl 100	1000	13,500
J D Sprecher	4	dsl	1000	Natl 80-B	1000	12,000
	6	dsl	750	Emsco A-550	750	9,000
Washakie County						
Anschutz Oil Co Inc	8	gas	900	M-CSCO U-15	650	8,500
Delta Drlg Co	18	dsl	600	Natl 75	650	9,500
R L Manning Co	2	gas-btne	375	Emsco 300	300	5,500
Mountain States Drlg Co Inc	14	dsl	800	Ideco M-1000	—	10,000
Weston County						
Olds & Wrather Drlg Co	1	dsl	300	Wisn Rdair Mogul	300	5,000
	2	gas	675	Emsco GB-350	675	7,000
	3	gas	1200	Beth 450	1200	11,000
	4	dsl	300	Wisn Gnt	300	4,000
Prairie Drlg Co Inc	1	gas	—	Crdwll RL Spdr	200	11,000

U. S. Contract CABLE TOOL Drilling Rigs

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
CALIFORNIA						
Ventura						
United Drlg Co	2	gas	75	2000	—	Keystone A-50
COLORADO						
Western Drlg Co Inc	5	btne	185	—	—	B Erie 48-L
	7	dsl	185	—	—	B Erie 48-L
IDAHO						
Bannock County						
Charles M Jameson	1	gas-gaso	—	3500	—	B Erie 36-L
ILLINOIS						
Christian County						
C W Strotman Drlg Co	1	gas	145	3600	4500	Crdwll H
V S & S Drlg Co	1	gas	—	—	2000	Wichtex
Clay County						
J W Rudy	3	btne	130	—	4000	Crdwll K
Shulman Bros	1	gas-gaso	—	4000	—	Crdwll H
V S & S Drlg Co	3	gas	—	3500	3500	Cooper
Coles County						
C W Strotman Drlg Co	3	gas	145	3600	4500	Crdwll H
Effingham County						
Cummins Drlg Co	C-7	gas-gaso	45	1000	1250	B Erie 22-W
Fayette County						
Cummins Drlg Co	C-1	gas-gaso	65	1500	2000	B Erie 24-L
	C-2	gas-gaso	65	1500	2000	B Erie 24-L
	C-3	gas-gaso	65	1500	2000	B Erie 60-L
	C-4	gas-gaso	65	1500	2000	B Erie 60-L
	C-5	gas-gaso	78	2500	3500	B Erie 28-L
	C-6	gas-gaso	78	2500	3500	B Erie 28-L
Hamilton County						
C E Brehn	4	btne	184	—	5000	Crdwll K
Kankakee County						
Moran Bros Inc	5	LPG-gas	175	4500	7000	B Erie 36-L
Lawrence County						
Payne Bros Drlg Co	3	dsl	150	3000	4000	B Erie 36-L
Marion County						
Perrine & Perrine Drlg Contr	2	btne	145	—	6000	B Erie 36-L
Graham Powell	1	btne	500	4200	4200	B Erie 36-L
Richland County						
Payne Bros Drlg Co	2	dsl	150	3000	4000	B Erie 36-L
Wabash County						
Payne Bros Drlg Co	1	dsl	150	3000	4000	B Erie 36-L
White County						
W L Diffier	1	gas	65	1500	2000	B Erie 60-L

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
INDIANA						
Gibson County						
Highland Oil	1	dsl	—	2000	—	B Erie 24-L
	2	dsl	—	3000	—	B Erie 28-L
Houchins Drlg Co	2	gaso	150	—	3500	Frnks Spddr
C W Strotman Drlg Co	2	gas	175	3500	4000	B Erie 36-L
	4	gas	175	3500	4500	Crdwll K
Posey County						
Lohmann-Johnson Drlg Co Inc	2	btne	—	4500	4500	Crdwll
IOWA						
Dallas County						
Kirby Oil Ind	—	gas-gaso	145	—	—	B Erie 28-L
KANSAS						
Barber County						
Mobile Drlg Co	5	gas	100	—	5500	Crdwll
Patton Drlg Co Inc	3	gas	—	—	—	Crdwll
Butler County						
Butler County Drlg Co	1	dsl	150	3600	—	Natl 3A-6
Chautauqua County						
Bennett Drlg Co	8	LPG	—	2750	3250	B Erie 28-L
Cowley County						
Butler County Drlg Co	2	LPG	140	3000	4500	Wlkr-Nr S-43
Rex & Morris Drlg Co	1	dsl	—	3500	4500	B Erie 36-L
Earl F Wakefield	2	gas-btne	220	5500	9500	B Erie 48-L
Ellis County						
Mobile Drlg Co	4	gas	100	—	5500	Crdwll
Graham County						
Bill's Drlg Serv	1	dsl	—	4500	4500	Crdwll Spdr Rl
McPherson County						
Carter Drlg Co	1	LPG	145	3500	6500	Wlkr-Nr S-43
Meade County						
Graham-Michaelis Drlg Co	1	dsl	175	3000	8000	Crdwll
Rice County						
SeRoBee Drlg Co Inc	1	btne	—	4000	—	Crdwll RL
	2	btne	—	4000	—	Crdwll RL
Russell County						
Shields Oil Producers	2	dsl	160	3500	7000	B Erie 48-L
	3	dsl	160	3500	7000	Crdwll RL
Earl F Wakefield	1	gas-btne	220	5500	9500	B Erie 48-L
Sedgwick County						
Carter Drlg Co	2	LPG	145	2000	4500	Wlkr-Nr C-33
	3	LPG	160	2000	4500	Wisn Mogul
Mobile Drlg Co	1	gas	75	—	3600	Crdwll
Kingman County						
Mobile Drlg Co	2	gas	100	—	5000	Crdwll
	3	gas	100	—	5500	Crdwll

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
Seward County						
Graham-Michaelis Drlg Co	3	dsl	150	3500	6000	B Erie 36
Sumner County						
Butler County Drlg Co	3	LPG	145	3500	5000	Wlkr-Nr S-43
KENTUCKY						
Bennett Drlg Co	6	LPG	—	1750	2250	B Erie 24-L
Henderson County						
Shulman Bros	2	gas-gaso	—	4000	—	Crdwll H
Temple Drlg Co Inc	1	btne	—	1800	1800	B Erie 24-L
MICHIGAN						
Allegan County						
Gordon Drlg Co	5	gas-LPG	150	4000	5000	Crdwll H
Hillsdale County						
McClure Oil Co	1	gas	145	5000	5000	B Erie 36-L
	2	gas	145	5000	5000	B Erie 36-L
Mecosta County						
Muskegon Development Co	—	dsl	150	5000	5000	Natl
Midland County						
Muskegon Development Co	—	dsl	150	5000	5000	Natl
Monroe County						
Bernhardt Drlg Co	1	btne-gas	175	4500	6000	B Erie 36
Montcalm County						
McClure Oil Co	4	gas	145	4500	4500	B Erie 36-L
Osceola County						
Muskegon Development Co	—	dsl	150	5000	5000	Natl
Saginaw County						
Muskegon Development Co	—	dsl	150	5000	5000	Natl
St. Clair County						
Bernhardt Drlg Co	2	dsl-gas-btne	125	5000	6000	B Erie 36-L
McClure Oil Co	3	gas	145	5000	5000	B Erie 36-L
Tuscola County						
Muskegon Development Co	—	LPG	165	6000	6000	Wlkr-Nr S-33
MONTANA						
Liberty County						
B & B Drlg Co (Montana)	1	gas	145	3500	—	B Erie 36-L
Pondera County						
J W Lawrence	2	gas-gaso	175	5000	—	B Erie
Teton County						
J W Lawrence	1	gas-gaso	125	3500	—	Natl
Toole County						
Olen Oil Corp	1	dsl	150	3000	5000	B Erie 36-L
	2	gas-LPG	150	3000	5000	B Erie 36-L
NEBRASKA						
Banner County						
Eatmon Drlg Co	1	prop	—	—	8000	Crdwll RL
	3	prop	—	—	6000	Wlkr-Nr
Kimball County						
Eatmon Drlg Co	2	prop	—	—	8000	Crdwll RL
Richardson County						
Nemaha Oil Co	1(wo)	gas	150	—	4500	Wichtex C-60
NEW MEXICO						
Eddy County						
Kersey & Co	1	gas-gaso	185	5000	5000	Natl 3
	2	gas-gaso	120	3000	3500	Wich Spddr 55
	3	gas-gaso	120	4000	4500	Wich Spddr 61
	4	gas-gaso	120	4000	4500	Natl 3
Needham Drlg Co	1	LPG	180	5000	—	Wich Spdr 66
	2	LPG	180	5000	—	Wich Spdr 66
Western Drlg Co Inc	3	btne	145	—	—	B Erie 36-L
S P Yates Drlg Co	3	LPG	150	3500	—	Wichita 55
	4	LPG	130	3000	—	Ft Wrth Spr J
	5	LPG	180	6000	—	Ft Wrth Jumbo J
	6	LPG	180	6000	—	Ft Wrth Jumbo J
Lea County						
Art West Drlg Co	3	gas	145	—	6000	Crdwll KL
OHIO						
Hancock County						
H J Lininger	2	dsl	175	3500	—	L C Moore
Hocking County						
R A Cooper Drlg Co Inc	1	gas	—	4000	4000	Natl 12
Wyandot County						
H J Lininger	1	gas-gaso	78	2500	—	Beth Cyclone
	3	gas-gaso	65	1800	—	Beth Cyclone
OKLAHOMA						
Creek County						
Bennett Drlg Co	2	LPG	—	3500	4000	Star 45
4-J Drlg and Well Serv Co	1	gaso	—	—	4500	B Erie 36-L
	2	gaso	—	—	3500	Wlkr-Neer
M L (Mike) Marrs Drlg Co	1	LPG	145	3500	4500	B Erie 36-L
	2	LPG	145	3500	5000	B Erie 36-L
	4	LPG	145	3500	5000	B Erie 36-L
Garfield County						
Hayward Drlg Co	2	gas	145	4000	—	Brwstr
Hughes County						
Troup & Suttles Inc	1	gas-gaso	145	—	9000	Wlkr-Nr 33
Kay County						
Mora Drlg Co	4	gas	330	7000	—	Wlsn Giant
Dave Morgan Drlg Co	—	LPG-gas	145	—	6500	Crdwll RL
Lincoln County						
Bodard Drlg Co	2	gas	225	7000	7000	Wlkr-Nr C-34
Noble County						
Seiboldt Drlg Co	1	gas-btne	165	7000	9000	Wlkr-Nr
Nowata County						
Bennett Drlg Co	3	LPG	—	2750	3250	B Erie 28-L
	10	LPG	—	2000	2500	B Erie 60-L
Okfuskee County						
Floyd R Hyer	1	gas-gaso-btne	60	2250	2750	Star Spddr K
	—	—	—	2200	—	Star Spddr K
Skinner & McDougal Drlg Co	1	gaso-btne	145	4000	6500	Crdwll
	2	gaso-btne	145	4000	5500	Wlkr-Nr
	3	gaso-btne	145	4000	5500	Crdwll
Okmulgee County						
Casselman Bros Drlg Co	1	LPG	145	6000	6000	Wlkr-Nr C-34
Ralph G Ladd	1	gas-gaso	65	1750	2500	Star Spddr K
Smallwood & Son Drlg Co	2	btne	—	3500	5500	B Erie 36-L
Osage County						
R L Horn & Sons Drlg Co	1	dsl	60	1600	2000	Star 72
Mora Drlg Co	7	gas	200	3500	—	Natl T-12
Tolson Drlg Co	1	LPG	145	4000	5000	Wlkr-Nr S-33
Payne County						
Foster Drlg Co Inc	1	prop	135	—	3500	Cooper
Pottawatomie County						
Mora Drlg Co	6	dsl	250	5000	—	Wlsn Mogul
Seminole County						
Mora Drlg Co	1	dsl	250	5000	—	Wlsn Mogul
Texas County						
Graham-Michaelis Drlg Co	4	dsl	175	—	8000	Crdwll RL
Tulsa County						
Bar-Lee Drlg Co	1	LPG	120	3000	4000	Wlkr-Nr 532
Triple S Drlg Co	—	btne	120	2500	3500	B Erie 60-L
Wagoner County						
C F Finefield	—	btne	100	2500	3500	Cyclone 46
	—	btne	100	2500	3500	Star 45ST
	—	btne	125	4000	5000	Keystone 35
Earl Knox Drlg Co	28L	LPG	90	2500	3000	B Erie 28-L
Washington County						
Bennett Drlg Co	5	LPG	—	2750	3250	B Erie 28-L
Delaware Drlg Co	2	LPG	110	1800	2500	Wichita 15
Straight & Kane	1	LPG	—	—	—	B Erie 28-L
	2	LPG	—	—	—	B Erie 28-L
PENNSYLVANIA						
Allegheny County						
Cecil Chisler & Son	2	gas	145	4000	5000	B Erie Spddr 36-L
Clearfield County						
Fairman Drlg Co	2	dsl	225	7500	8000	B Erie Spddr 48-L
	3	gas	225	7500	8000	B Erie Spddr 48-L
	4	gas	225	7500	8000	B Erie Spddr 48-L
	5	dsl	170	5000	6000	B Erie Spddr 36-L
Potter County						
Fairman Drlg Co	1	dsl	225	7500	8000	B Erie Spddr 48-L
TEXAS						
Carson County						
J R McGill	2	gas-gaso	145	4500	4500	B Erie
Cochran County						
Western Drlg Co Inc	4	btne	185	—	—	B Erie 48-L
	10	btne	185	—	—	B Erie 48-L
Coleman County						
W H McGarr Ind	2	gas-LPG	100	2500	2500	Ft Wrth Spr D
Collingsworth County						
C P Drlg Co	8	gas-btne	125	3500	4000	B Erie 36-L
Eastland County						
Kent & Preston	2	btne	120	4000	4000	Ft Wrth Jumbo
Ector County						
McQueen & Stout Drlg Co	16	LPG	185	5000	5000	Crdwll RL
	18	LPG	145	5000	—	Natl 3
	20	LPG	185	5000	5000	Crdwll RL
Art West Drlg Co	5	gas	185	—	8000	Crdwll RL
	9	gas	185	—	9000	Wlsn Giant
	10	dsl	125	—	8000	Crdwll RL

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
Gaines County						
Western Drlg Co Inc	8	btne	185	—	—	B Erie 48-L
Gray County						
C P Drlg Co	3	gas-btne	125	3500	4000	B Erie 36-L
	6	gas-btne	125	3500	4000	Wisn Mogul
King Edwards (Edwards Drlg Co)	11	btne	—	—	—	Wlkr-Nr Spddr
Holt Bros Drlg Co	1	LPG	145	3500	6000	B Erie 36-L
Murphy & McKernan	1	gas-gaso	145	4500	5500	B Erie 36-L
	2	gas-gaso	145	4500	5500	B Erie 36-L
Hansford County						
Moran Bros Inc	17	LPG-gas	175	4500	7000	B Erie 36-L
Howard County						
R L Bob Clark Drlg Co	4	LPG	140	3500	4500	Wlkr-Nr S-43
Hutchinson County						
J R McGill	1	gas-gaso	145	4000	4000	B Erie
Robinson Bros Drlg Co	1	gas	200	4500	5000	B Erie 48-L
Irion County						
James Smith Drlg Contr	1	gaso-LPG	145	3500	4000	B Erie 36-L Spdr
Lubbock County						
Western Drlg Co Inc	2	btne	145	—	—	B Erie 36-L
Maverick County						
Errol Elkins Drlg Co	2	LPG	150	5000	6500	B Erie 36-L
W H McGarr Ind	1	gas-LPG	120	4500	4500	Wichita 61
McCulloch County						
Kent & Preston	1	dsl	160	6000	—	Ft Wrth J-37
Mitchell County						
Ellis Drlg Corp	2	btne	45	2400	3000	B Erie 28-L
	3	btne	60	4000	5000	B Erie 36-L
Nolan County						
Jones Well Serv Co	3	gas-LPG	145	3500	6000	B Erie 36-L
Ochiltree County						
Graham-Michaelis Drlg Co	2	dsl	175	3000	8000	Crdwll
Odessa County						
Carey & Parker Inc	1	gas-gaso-btne	—	—	4000	Clark 71
	2	gas-gaso-btne	—	—	10,000	Crdwll RL
	4	gas-gaso-btne	—	—	10,000	Crdwll RL
	5	gas-gaso-btne	—	—	9000	Crdwll RL
Palo Pinto County						
Oney Drlg Co	2	gas	145	5500	—	Wichita
Pecos County						
Hissom Drlg Co	5	gas	180	7500	10,000	Crdwll RL
C C Pollard	—	gas	150	4000	5000	Wich 61 Spddr
Reagan County						
Wilbanks & Rutter Drlg Co	2	gas	—	—	—	—
Reeves County						
Ford Chapman	1	LPG	120	4500	5500	B Erie 36-L
	2	LPG	225	7000	8500	B Erie 48-L
Scurry County						
Ellis Drlg Corp	1	btne	45	2400	3000	B Erie 28-L
Sutton County						
Wesley C Young Drlg Co	—	LPG	145	3500	4500	B Erie 36-L
	—	LPG	100	2800	3500	B Erie 28-L
	—	LPG	40	1500	2000	B Erie 22-W

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
Taylor County						
Jones Well Serv Co	1	gas-LPG	145	3500	6000	B Erie 36-L
	2	gas-LPG	145	3500	6000	B Erie 36-L
West Central Drlg Co	2	gas-gaso	—	—	—	Ft Wrth J
Throckmorton County						
Lin-Mour Drlg Co	2	gas	125	—	6500	Wlkr-Nr C-34
Upton County						
Brown & Thorp Drlg Co	2	LPG	135	5500	—	Wichita 66
	3	LPG	180	4000	—	Ft Wrth F-37
	4	LPG	135	4000	—	Ft Wrth F
	5	LPG	135	4000	—	Ft Wrth D
	6	LPG	180	4000	—	Ft Wrth F
	7	LPG	135	4500	—	Wichita 61
	8	LPG	135	3500	—	Ft Wrth D
	9	LPG	135	3500	—	Ft Wrth D
	10	LPG	135	3500	—	Wichita 55
	11	LPG	135	3500	—	Ft Wrth D
Buck Jones Drlg Co	1	btne	140	4000	4000	Wlkr-Nr 33
	2	btne	100	2500	2500	Wlkr-Nr 32
	3	btne	150	5000	5000	Natl 3
Ward County						
Bolin Oil Co & D H Bolin	8	gas	145	4500	—	Wlkr-Nr S-45
Eastland Drlg Co	6	gas	125	4500	6000	B Erie
C C Pollard	—	dsl	150	5000	6000	Wich 66 Spddr
Art West Drlg Co	6	gas	145	—	8000	Crdwll RL
	8	gas	145	—	8000	Crdwll RL
Wichita County						
Ashton Well Serv	1	gas	65	—	3000	Wlkr-Nr C-31
Lin-Mour Drlg Co	3	btne	100	5000	—	Wlkr-Nr C-33
Ramey Well Serv	2	LPG	140	—	8000	Wichtex E 75
Wilbarger County						
Ramey Well Serv	1	LPG	140	—	8000	Wichtex E 75
Winkler County						
R L Bob Clark Drlg Co	2	LPG	145	3500	4500	B Erie 36-L
Art West Drlg Co	7	gas	145	—	8000	Crdwll RL
Young County						
Oney Drlg Co	1	gas	165	5500	—	Wichita
	3	gas	210	6500	—	Wichita
Louis Pitcock Drlg Co	3	dsl	225	6000	7000	Wich 66
WEST VIRGINIA						
Logan County						
Allen Drlg Co	2	gas	145	5000	6000	B Erie Spddr 36-L
	7	gas	175	3500	5000	Natl Mach 2
Marshall County						
Cecil Chisler & Son	1	gas	78	3500	3500	B Erie Spddr 28-L
Mingo County						
Allen Drlg Co	1	gas	128	5000	6000	B Erie Spddr 36-L
Wyoming County						
Allen Drlg Co	3	gas	128	5000	6000	B Erie Spddr 36-L
WYOMING						
Converse County						
Morrison Drlg Co Inc (Wyo)	2	btne	185	5500	8000	Crdwll
	3	btne	185	5500	8000	Crdwll
Sweetwater County						
Morrison Drlg Co Inc (Wyo)	1	btne	145	4500	6000	Crdwll

CANADIAN DRILLING CONTRACTORS

ROTARY AND CABLE TOOLS

ALPHABETICAL LISTING

Arnim Drilling Ltd 133 Sixth Ave East Calgary Alberta Canada
Peter Bawden Drlg Ltd 640 Seventh Ave W Calgary Alberta Canada
Bernco Drlg Ltd 507 Lancaster Bldg Calgary Alberta Canada
Big Horn Drlg Ltd 6530 100th St Edmonton Alberta Canada
Border Drlg Co Ltd Box 40 Lloydminster Alberta Canada
Brinkerhoff Drlg Co Ltd 1001 Mobil Oil Bldg Calgary Alberta Canada
Brown Drlg Ltd 10509 81st Ave Edmonton Alberta Canada
Cactus Drlg Corp Ltd Box 853 Calgary Alberta Canada
Can American Drlg Ltd 320 Seventh Ave W Calgary Alberta Canada
Cascade Drlg Co Ltd 330 9th Ave W Calgary Alberta Canada
Central-Del Rio Oils Ltd — Drlg Div 224 Ninth Ave W Calgary Alberta Canada
Commonwealth Drlg Co Ltd 122 Eighth Ave W Calgary Alberta Canada
Coultis Drlg Ltd 1724 Suffolk St Calgary Alberta Canada
Double A Drlg Co Ltd 709 Eighth Ave W Calgary Alberta Canada
Duke Drlg Co Ltd 239 Eighth Ave W Calgary Alberta Canada
General Petroleums of Canada Ltd 224 Ninth Ave W Calgary Alberta Canada
Gustavson Drlg Co Ltd 203 Empire Bldg Calgary Alberta Canada
Hi-Tower Drlg Co Ltd 400 Lancaster Bldg Calgary Alberta Canada
Hunter Drlg Ltd 602 Seventh Ave W Calgary Alberta Canada
Jennings Drlg Co (Alberta) Ltd 133 Sixth Ave SE Rm 201 Calgary Alberta Canada
Kenyon's Drlg & Serv Co Ltd 10439 82nd Ave Edmonton Alberta Canada
L & J Drlg Ltd 7 Empire Bldg Calgary Alberta Canada
Lohmann-Johnson Drlg Co Ltd 208 Bamlett Bldg Calgary Alberta Canada

Guthrie McLaren Drlg Ltd Box 638 Edmonton Alberta Canada
Moore Drlg Co Ltd 502 Empire Bldg Calgary Alberta Canada
Parker Drlg Co of Canada Ltd 409 Eighth Ave W Calgary Alberta Canada
Patterson & Culver Box 92 Dunnville Ontario Canada
Pennant Drlg Co Ltd 108-A Eighth Ave W Calgary Alberta Canada
Petrolia Drlg Co Ltd 1410 — 4th St SW Calgary Alberta Canada
Precision Drlg Co Ltd 1134 Eighth Ave W Calgary Alberta Canada
Regent Drlg Co Ltd Box 421 Edmonton Alberta Canada
Rine Drlg Co of Canda Ltd 534 8th Ave SW Calgary Alberta Canada
Ryland Drlg Ltd 10318 82nd Ave Edmonton Alberta Canada
Trident Drlg Co Ltd 803 Eighth St W Calgary Alberta Canada
Trinity Canadian Drlg Co 1001 F R Webster Bldg 237 Seventh Ave W Calgary Alberta Canada
Union Rotary Corp 155 Wellington St Sarnia Ontario Canada

Canadian Contract ROTARY Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALBERTA PROVINCE						
Arrow Drlg Co	6	dsl	250	Emsco GB-350	350	7,000
	8	dsl	250	Emsco GB-350	480	7,000
	19	dsl	250	Emsco GB-350	480	7,000
	21	dsl	1250	Emsco J-1250	1400	14,000
	26	dsl	975	Emsco GB-800	1200	13,000
Gardner Bros Drlg Co Inc	7	dsl	850	Natl 75	1000	12,000
Jennings Drlg Co (Alberta) Ltd	1	dsl	300	Beth C-50	330	6,000 7,000/3½"
	2	dsl	300	Beth C-50	300	6,000 7,000/3½"
	3	dsl	880	M-CSCO U-15	880	9,000 10,000/3½"
	4	dsl	300	Beth 55 Twstr	300	6,000 7,000/3½"
Athabasca						
Commonwealth Drlg Co Ltd	25	dsl	425	M-CSCO U-34D	300	5,500
Hi-Tower Drlg Co Ltd	8	dsl	570	M-CSCO U-15	600	8,000
Bassano						
Cascade Drlg Co Ltd	6	dsl	—	Natl T-20	—	4,500
General Pet of Canada Ltd	12	dsl	250	Natl T-20	250	4,600
Bellevue						
Regent Drlg Co Ltd	7	dsl	1200	Natl 125	1500	15,000
Bentley						
Brinkerhoff Drlg Co Ltd	12	dsl	200	Natl T-32	300	6,000
Berland River						
General Pet of Canada Ltd	18	dsl	1400	Natl 80-B	1150	12,000
Bigdray						
Commonwealth Drlg Co Ltd	16	dsl	800	Emsco GB-350	720	7,000
Blackfalds						
Regent Drlg Co Ltd	28	dsl	500	Natl 50-A	520	7,000
Brooks						
Gustavson Drlg Co Ltd	2	dsl	500	Natl T-32	250	6,500
Burnt Timber Creek						
Cascade Drlg Co Ltd	14	dsl	—	M-CSCO U-20	—	14,000
Calgary						
General Pet of Canada Ltd	10	dsl	1400	Natl 80	1000	12,000
Cessford						
Precision Drlg Co Ltd	3	dsl	276	Ideco H-30-D	276	5,000
	4	dsl	276	Natl T-20	276	5,000
	6	dsl	276	Ideco H-30-D	276	5,000
Chard						
Precision Drlg Co Ltd	2	dsl	276	Ideco H-20-D	184	3,500
	8	dsl	276	Ideco H-30-D	276	5,000
Chip Lake						
Trident Drlg Co Ltd	1	dsl	—	"Oilwell" 64B	530	6,000
Clear Hills						
Parker Drlg Co of Canada Ltd	4	dsl	800	"Oilwell" 76	1100	12,500
Coutts						
Peter Bawden Drlg Ltd	4	dsl	220	Crdwll RL	205	4,500
Cynthia						
Regent Drlg Co Ltd	1	dsl	260	Brwstr N-4	260	6,000
Daysland						
Big Horn Drlg Ltd	1	dsl	300	Crdwll S-350	300	5,000
Didsbury						
Hunter Drlg Ltd	2	dsl	900	Crdwll J-700	1150	12,000
	6	dsl	750	Brwstr N-75	780	10,000
Drayton Valley						
Commonwealth Drlg Co Ltd	3	dsl	690	Natl 50	600	6,500
Drumheller						
Brown Drlg Ltd	2	dsl	550	Natl 50	550	7,500
Commonwealth Drlg Co Ltd	13	dsl	630	Emsco GA-350	720	6,500
Edson						
Pennant Drlg Co Ltd	5	dsl	900	M-CSCO U-40	900	11,500
	6	dsl	1350	M-CSCO U-40	1200	11,500
Trident Drlg Co Ltd	8	dsl	—	"Oilwell" 96	1680	15,500
Forestburg						
Big Horn Drlg Ltd	3	dsl	300	Crdwll L-350	300	4,500
Fort Assiniboine						
Regent Drlg Co Ltd	3	dsl	720	Brwstr N-55	520	8,000
	9	dsl	750	Brwstr N-75	780	10,000
	25	dsl	750	Brwstr N-75	780	10,000
Gem						
Cascade Drlg Co Ltd	16	dsl	250	M-CSCO U-34	250	5,000
Golden Spike						
General Pet of Canada Ltd	4	dsl	500	Natl 50-A	650	7,500
Grande Prairie						
Pennant Drlg Co Ltd	4	dsl	1000	Crdwll 0	650	9,500
Harmatton						
Commonwealth Drlg Co Ltd	9	dsl	1020	Ideco 700	940	10,000
	28	dsl	920	Natl 55	1000	10,000
High Prairie						
Regent Drlg Co Ltd	24	dsl	720	Brwstr N-7	520	8,000
Hughenden						
Peter Bawden Drlg Ltd	3	dsl	270	Crdwll S	180	4,500
Moore Drlg Co Ltd	6	dsl	400	Emsco 300	300	5,000
	10	dsl	640	Emsco 350	640	6,500
Innisfail						
Commonwealth Drlg Co Ltd	8	dsl	690	Brwstr N-7	600	8,000
Duke Drlg Co Ltd	6	dsl	850	M-CSCO U-20	1386	15,000
	7	dsl	850	M-CSCO U-20	1386	15,000
General Pet of Canada Ltd	16	dsl	1050	Natl 55	1150	10,000
Hi-Tower Drlg Co Ltd	6	dsl	755	"Oilwell" 76	800	12,000
	10	dsl	755	"Oilwell" 76	800	12,000
Parker Drlg Co of Canada Ltd	3	dsl	765	"Oilwell" 76	1005	12,000
	9	dsl	765	Natl 125	1005	14,000
Joffre						
Peter Bawden Drlg Ltd	6	dsl	722	M-CSCO U-36A	722	8,500
General Pet of Canada Ltd	6	dsl	400	Natl 50-A	500	7,000
Trident Drlg Co Ltd	13	dsl	—	"Oilwell" 66	530	7,500
Kaybob						
Peter Bawden Drlg Ltd	2	dsl	810	Natl 55	810	10,000
Brinkerhoff Drlg Co Ltd	18	dsl	625	Emsco GC-500	846	10,000
Moore Drlg Co Ltd	1	dsl	1000	M-CSCO U-40	1000	10,000
Pennant Drlg Co Ltd	1	dsl	775	M-CSCO U-40	775	11,500
Keystone						
Peter Bawden Drlg Ltd	1	dsl	415	Natl T-32	275	6,000
Brown Drlg Ltd	1	dsl	275	Cardwell S	—	5,000
Commonwealth Drlg Co Ltd	7	dsl	750	Natl 50	530	6,500
Rine Drlg Co of Canada Ltd	2	dsl	590	Brwstr N-55	720	8,500
Ryland Drlg Ltd	1	dsl	600	Emsco 450	640	7,500
Kinuso						
Hi-Tower Drlg Co Ltd	3	dsl	525	"Oilwell" 66	550	8,000
Lac La Biche						
Petrolia Drlg Co Ltd	10	dsl	300	M-CSCO U-34	300	5,400
Leduc						
Moore Drlg Co Ltd	2	dsl	600	Emsco 450	640	7,500
Ledgepole						
Regent Drlg Co Ltd	30	dsl	260	Ideco H-40	260	6,000
Lloydminster						
Peter Bawden Drlg Ltd	14	dsl	142	Crdwll	100	2,500
Border Drlg Co Ltd	1	dsl	175	Crdwll L	150	3,500
Mc Murray						
Big Horn Drlg Ltd	2	dsl	250	Crdwll L	180	3,500
Medicine Hat						
Coultis Drlg Ltd	1	dsl	248	Ideco H-25-D	235	3,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Nampa						
Duke Drlg Co Ltd	8	dsl	500	M-CSCO U-40	670	11,500
Trident Drlg Co Ltd	10	dsl	—	Emsco GB-350	450	7,000
	14	dsl	—	"Oilwell" 76	795	10,500
New Norway						
Ryland Drlg Ltd	2	dsl	670	Natl 50	690	7,500
Normandville						
Gustavson Drlg Co Ltd	5	dsl	420	Natl T-45	420	7,500
Olds						
Pennant Drlg Co Ltd	2	dsl	1155	Brwstr N-7	755	8,500
Okotoks						
Trident Drlg Co Ltd	9	dsl	—	"Oilwell" 76	795	10,500
Peace River						
Moore Drlg Co Ltd	5	dsl	600	M-CSCO U-15	600	7,500
Pembina						
Peter Bawden Drlg Ltd	5	dsl	440	Natl T-32	270	5,500
	8	dsl	300	Natl T-32	300	6,500
	12	dsl	250	Natl T-12	225	4,000
Brinkerhoff Drlg Co Ltd	15	dsl	370	Natl 50-A	600	8,500
	16	dsl	370	Emsco GA-350	450	7,500
Cactus Drlg Corp Ltd	3	dsl	420	Natl T-32	280	6,000
Cascade Drlg Co Ltd	1	dsl	—	Natl 50	—	6,500
	3	dsl	—	Natl 50	—	6,500
	8	dsl	—	Natl 50	—	6,500
	9	dsl	—	Natl T-32	—	5,500
	10	dsl	—	Natl 50	—	6,500
Commonwealth Drlg Co Ltd	17	dsl	630	Emsco GB-350	720	6,000
Gustavson Drlg Co Ltd	1	dsl	500	Natl 50	500	7,500
	3	dsl	275	Ideco H-40	300	6,500
Hi-Tower Drlg Co Ltd	4	dsl	350	Natl 50	450	6,500
Parker Drlg Co of Can Ltd	11	dsl	400	Natl 50	500	6,500
Ryland Drlg Ltd	4	dsl	450	Emsco 350	475	7,000
Trident Drlg Co Ltd	3	dsl	—	"Oilwell" 64-B	530	6,000
Pincher Creek						
Brinkerhoff Drlg Co Ltd	8	dsl	900	Natl 110	1200	15,000
	19	dsl	850	Emsco A-800	1269	14,000
Red Deer						
Moore Drlg Co Ltd	7	dsl	960	Beth S-55	640	8,500
	8	dsl	640	Beth S-55	640	7,500
	9	dsl	640	Ideco 525	640	8,500
Trident Drlg Co Ltd	7	dsl	—	"Oilwell" 76	795	10,500
Red Earth						
Commonwealth Drlg Co Ltd	10	dsl	550	Ideco H-35D	300	6,500
	11	dsl	260	Ideco H-40D	300	5,500
	22	dsl	750	Natl 50	530	6,500
Rimbey						
Duke Drlg Co Ltd	9	dsl	500	M-CSCO U-15	650	9,000
Rocky Mountain House						
Parker Drlg Co of Canada Ltd	1	dsl	800	"Oilwell" 76	1275	11,500
Savannah Creek						
Peter Bawden Drlg Ltd	10	dsl	900	Natl 80-B	1200	13,500
Simonette River						
Can American Drlg Ltd	3	dsl	750	Natl 80-B	1645	13,000
Cascade Drlg Co Ltd	12	dsl	—	Natl 80-B	—	14,000
Petrolia Drlg Co Ltd	11	dsl	1005	M-CSCO U-40	1005	12,000
Slave Lake						
Duke Drlg Co Ltd	2	dsl	650	Natl 50	650	8,000
(Southeastern)						
Bernco Drlg Ltd	1	dsl	352	Frnks SA-4000	335	4,000 5,000/3½"
Cactus Drlg Corp Ltd	4	dsl	215	Emsco GB-160	275	4,000
South Pouce Coupe						
Parker Drlg Co of Canada Ltd	8	dsl	400	Natl 50	500	6,500
Standard						
Hi-Tower Drlg Co Ltd	5	dsl	350	Natl 50	450	5,000
	9	dsl	285	Crdwll D	300	5,000
Stettler						
General Pet of Canada Ltd	19	dsl	435	Natl T-32	175	5,500
Parker Drlg Co of Canada Ltd	5	dsl	420	Natl 50	420	7,000
	6	dsl	420	"Oilwell" 52-T	420	6,500
Sturgeon Lake						
Peter Bawden Drlg Ltd	7	dsl	720	Natl 55	720	9,500
Commonwealth Drlg Co Ltd	19	dsl	735	Natl 50-A	790	9,500
Sundre						
General Pet of Canada Ltd	3	dsl	425	Natl 50-A	650	7,500
	11	dsl	1400	Natl 80-B	1150	12,000
	15	dsl	1400	Natl 55	1050	10,000
	17	dsl	1400	Natl 55	1050	10,000
Swan Hills						
Peter Bawden Drlg Ltd	9	dsl	1000	M-CSCO U-40	1000	12,000
Brinkerhoff Drlg Co Ltd	1	dsl	625	Emsco GC-500	846	10,000
Cascade Drlg Co Ltd	7	dsl	—	Natl 50-A	—	7,500
	17	dsl	—	Natl 75	—	12,000
Commonwealth Drlg Co Ltd	21	dsl	1250	Ideco 7-11	900	10,500
	23	dsl	905	Emsco GC-500	800	9,500
Double-A Drlg Co Ltd	2	dsl	800	Ideco H-525	600	9,000
General Pet of Canada Ltd	5	dsl	800	Natl 80-B	1000	12,000
Hi-Tower Drlg Co Ltd	1	dsl	525	"Oilwell" 66	550	8,000
	7	dsl	525	"Oilwell" 66	550	8,000
Kenyon's Drlg & Serv Ltd	11	dsl	—	Crdwll 151	—	5,000/3½"
Parker Drlg Co of Canada Ltd	2	dsl	615	"Oilwell" 76	750	11,000
Regent Drlg Co Ltd	2	dsl	520	Brwstr N-55	520	8,000
Tangent						
Gustavson Drlg Co Ltd	4	dsl	850	Natl 55	850	10,000
Tellerdville						
General Pet of Canada Ltd	14	dsl	350	Crdwll OA	500	6,500
Valleyview						
Petrolia Drlg Co Ltd	7	dsl	330	Natl 50	330	7,500
Virginia Hills						
Arnim Drlg Ltd	1	dsl	300	Crdwll J-450	300	10,000/3½"
Parker Drlg Co of Canada Ltd	12	dsl	650	"Oilwell" 66	800	9,000
Trident Drlg Co Ltd	4	dsl	—	Natl 100	1140	12,000
Wabiskaw						
Guthrie McLaren Drlg Ltd	2	dsl	500	"Oilwell" T-52	350	7,500
Waterton Lake						
Commonwealth Drlg Co Ltd	1	dsl	1350	Natl 110	1500	14,000
	26	dsl	1275	Natl 80-B	1410	12,000
Whitecourt						
Brinkerhoff Drlg Co Ltd	21	dsl	850	Emsco GB-800	1269	13,500
	22	dsl	900	Natl 110	1450	15,000
Duke Drlg Co Ltd	5	dsl	700	M-CSCO U-20	1386	15,000
Parker Drlg Co of Canada Ltd	7	dsl	600	Natl 55	670	9,000
Regent Drlg Co Ltd	8	dsl	750	Brwstr N-75	780	10,000
Trinity Canadian Drlg Co	7	dsl	875	Emsco GC-500	720	10,000
BRITISH COLUMBIA PROVINCE						
Arrow Drlg Co	4	dsl	500	Emsco CB-350	600	7,000
	7	dsl	975	Emsco GC-500	900	9,000
Alcan Highway-Mile 132						
Commonwealth Drlg Co Ltd	15	dsl	800	Brwstr N-7	600	8,000
Alcan Highway-Mile 248						
Trinity Canadian Drlg Co	1	dsl	995	Emsco GC-500	770	10,000
Beatton River						
Guthrie McLaren Drlg Ltd	1	dsl	300	"Oilwell" T-52	350	7,000
Trinity Canadian Drlg Co	3	dsl	720	Emsco 350	670	7,000
	4	dsl	990	Natl 80-B	990	12,000
Bush Mountain						
General Pet of Canada Ltd	7	dsl	1400	Natl 80-B	1300	13,000
Dawson Creek						
Trinity Canadian Drlg Co	5	dsl	1250	Emsco A-800	1150	15,000
Ft. Nelson						
Commonwealth Drlg Co Ltd	20	dsl	1270	Ideco 7-11	900	10,500
Trident Drlg Co Ltd	6	dsl	—	Emsco 500	530	8,000
Ft. St. John						
Cascade Drlg Co Ltd	2	dsl	—	Wisn Roadair	—	9,200
	4	dsl	—	Natl 50-A	—	7,500
Regent Drlg Co Ltd	5	dsl	720	Brwstr N-7	520	8,000
Gulf States						
Brinkerhoff Drlg Co Ltd	14	dsl	370	Emsco GB-500	600	8,500
	20	dsl	370	Natl 50-A	450	8,500
Milligan Creek						
Cascade Drlg Co Ltd	11	dsl	—	Crdwll D	—	5,500
(Northeastern)						
Cactus Drlg Corp Ltd	5	dsl	675	Emsco GB-500	675	8,500
	6	dsl	555	Emsco GB-350	555	7,000
	7	dsl	675	Emsco GB-350	675	7,500
Parker Drlg Co of Canada Ltd	10	dsl	400	Natl 50-A	500	7,000
Queen Charlotte Islands						
Cascade Drlg Co Ltd	5	dsl	—	Natl 50-A	—	7,500
Trutch						
Trident Drlg Co Ltd	12	dsl	—	M-CSCO U-15	530	7,500
MANITOBA PROVINCE						
Minnedosa						
Commonwealth Drlg Co Ltd	18	dsl	260	Ideco H-25D	300	4,500
Virden						
Coultis Drlg Ltd	3	dsl	248	Wgnr Mrhse TD7	150	3,000
NORTHWEST TERRITORY						
Hay River						
Peter Bawden Drlg Ltd	11	dsl	250	Natl T-32	300	5,000
Regent Drlg Co Ltd	21	dsl	260	Brwstr N-4	260	9,000/3½"
	26	dsl	260	Ideco H-40	260	6,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ONTARIO PROVINCE						
Eakle & Holder Drlg Co	4	dsl	300	Natl T-20	300	5,500
Lambton						
Union Rotary Corp	1	gas-LPG	200	Natl 40	180	4,000
	3	gas-LPG	200	Natl 40	180	4,000
Medicine River						
Lohmann-Johnson Drlg Co Ltd	2	dsl	218	M-CSCO U-15	500	9,000
SASKATCHEWAN PROVINCE						
L & J Drlg Ltd	5	dsl	300	Crdwll "S"	440	4,500
Alameda						
Can American Drlg Ltd	7	dsl	260	Natl T-20	260	5,000
Calder						
Coultis Drlg Ltd	2	dsl	250	Wisn Torcair	250	4,000
Carnduff						
Can American Drlg Ltd	4	dsl	260	Natl T-20	260	5,000
General Pet of Canada Ltd	21	dsl	250	Natl T-20	185	4,600
Hunter Drlg Ltd	3	dsl	450	Crdwll	260	6,000
Choiceland						
Regent Drlg Co Ltd	27	dsl	260	Brwstr N-4	260	6,000
Coleville						
Rine Drlg Co of Canada Ltd	1	dsl	300	Brwstr N-45	350	6,500
Dinsmore						
Commonwealth Drlg Co Ltd	14	dsl	580	Ideco H-40D	660	5,500
Edgeworth						
Can American Drlg Ltd	2	dsl	650	Natl T-55	975	10,000
Estevan						
Commonwealth Drlg Co Ltd	2	dsl	550	Natl 50	420	6,500
Double-A Drlg Co Ltd	1	dsl	340	Ideco H-30	265	4,500
	3	dsl	340	Ideco H-40	265	6,000
Kenyon's Drlg & Serv Ltd	12	dsl	—	Frnks Comet 658	—	5,000
Frobisher						
Regent Drlg Co Ltd	4	dsl	260	Brwstr N-4	260	6,000
Glen Ewen						
General Pet of Canada Ltd	2	dsl	250	M-CSCO U-34	250	4,800
	20	dsl	275	Emsco GB250T	275	5,000
Halkirk						
General Pet of Canada Ltd	9	dsl	375	Natl T-25	250	5,500
Harptree						
Commonwealth Drlg Co Ltd	6	dsl	690	Ideco M-750	600	7,000
Holdfast						
General Pet of Canada Ltd	1	dsl	250	Natl 50	525	6,500
Lampman						
Precision Drlg Co Ltd	7	dsl	550	Ideco 525-D	550	7,500
Midale						
Commonwealth Drlg Co Ltd	24	dsl	520	Natl 50	600	6,000
Regent Drlg Co Ltd	23	dsl	260	Brwstr N-4	260	6,000
	29	dsl	260	Brwstr N-4	260	6,000
North Portal						
Can American Drlg Ltd	1	dsl	350	Natl T-32	275	6,000
Oxbow						
Regent Drlg Co Ltd	22	dsl	260	Brwstr N-4	260	6,000
Radville						
General Pet of Canada Ltd	8	dsl	250	Natl T-25	250	5,000
Raven River						
Lohmann-Johnson Drlg Co Ltd	1	dsl	550	"Oilwell" 66	550	9,000
Saskatoon						
Precision Drlg Co Ltd	12	dsl	276	Natl T-20	276	5,000
(Southeastern)						
Moore Drlg Co Ltd	3	dsl	320	Brwstr N-4	190	5,000
	4	dsl	330	Emsco 300	300	5,000
Steelman						
Commonwealth Drlg Co Ltd	4	dsl	260	Ideco H-40D	300	6,000
	5	dsl	260	Emsco GA-250T	310	5,000
	12	dsl	260	Natl T-32	300	5,500
Ryland Drlg Ltd	3	dsl	320	Natl T-32	320	6,000
Swift Current						
Precision Drlg Co Ltd	1	dsl	276	Ideco H-30-D	276	5,000
	5	dsl	276	Brwstr N-4	276	5,000
	9	dsl	276	Brwstr N-4	276	5,000
	10	dsl	550	Ideco 525-D	550	7,500
	11	dsl	550	Crdwll D	550	6,000
Wapella						
Can American Drlg Ltd	5	dsl	375	Natl T-32	320	6,000
Weyburn						
Central-Del Rio Oils Ltd	1	dsl	500	Natl 50	500	6,500
	2	dsl	285	Crdwll TR 66	245	5,000
Hunter Drlg Ltd	1	dsl	450	Crdwll	260	6,000
Yorkton						
Can American Drlg Ltd	6	dsl	275	Natl T-12	260	3,500

Canadian Cable Tools

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
ALBERTA PROVINCE						
Bernco Drlg Ltd	1	dsl	335	5000	8000	Frnks SA-4000
ONTARIO PROVINCE						
Hold County						
Patterson & Culver	1	gas	80	2500	3500	B Erie 28-L
	2	gas	60	1500	2000	B Erie 24-L
	3	gas	60	1500	2000	B Erie 24-L

Some Contract Rigs in Foreign Service

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ARGENTINA						
Kermac Drlg Co of Venezuela	3	dsl	800	Natl 75	1000	11,500
	28	dsl	800	Natl 75	1000	11,500
	41	dsl	800	Natl 75	1000	11,500
	42	dsl	800	Natl 75	1000	11,500
	51	dsl	800	Natl 75	1000	11,500
AUSTRALIA						
Delta Drlg Co	41	dsl	1300	Natl 130	1400	16,000
BOLIVIA						
Big Chief Drlg Co	29	dsl	1875	Emsco 1250	1815	16,000
	31	gas	1545	Emsco 800	1515	13,500
	37	gas	1875	Emsco 1250	1815	16,000
BRAZIL						
Brantly Drlg Co (Intl) Inc	1	dsl	850	"Oilwell" 52-T	500	7,000
BRITISH HONDURAS						
Punta Gorda						
Kerr-McGee Oil Ind Inc	50	dsl	1000	Natl 55	770	10,000
COLOMBIA						
El Centro						
Llano Drlg Co	8	dsl	800	Ideco H-30	300	4,500
CUBA						
C J Simpson Drlg Co	1C	dsl-gas	—	Natl T-32	320	5,000
	2C	dsl-gas	—	M-CSCO U-40	900	14,000
	3C	dsl-gas	—	Emsco D-450	700	8,500
DENMARK						
K L Kellogg & Sons	33	gas	1750	Emsco GB-800	1050	12,000
ITALY						
Abruzzo						
Delta Overseas Drlg Co	2	dsl	260	Ideco H-30	300	4,500
Caltagirone						
Delta Overseas Drlg Co	3	dsl	500	Emsco GB-500	500	8,500
	4	dsl	900	Emsco 800	900	11,000
Rome						
Delta Overseas Drlg Co	1	dsl	900	Ansaldo 2000	600	7,000
JORDAN						
Parker Drlg Co	46	gas	—	Natl 75	700	10,000
LIBYA						
Camdrill International Inc	—	dsl	255	Ideco H-30-D	300	4,500
	2	dsl	1000	Natl 110	2400	13,000
"Desert Star"		dsl	1290	Ideco 525-D	860	9,000
MEXICO						
Del Mar Drlg Co	3	gas	690	Natl 75	750	10,500
Walters Drlg Co Inc	11	gas	150	Mayhew 1000	150	600/2⅞"
QUATEMALA						
Fallabon						
Kerr-McGee Oil Ind Inc	14	dsl	695	Natl 50	630	9,000
VENEZUELA						
Santa Fe Drlg Co	23	dsl	300	Ideco H-40	300	6,000
Eastern						
Helmerich & Payne Inc	61	dsl	—	Natl 125	—	—
	63	stm	—	Natl 34-10	—	—
	64	stm	—	Natl 34-10	—	—
	65	dsl	—	Natl 50-A	—	—
	66	dsl	—	Natl 125	—	—
	68	stm	—	Natl 34-10	—	—
	69	stm	—	Natl 34-10	—	—
Western						
Helmerich & Payne Inc	62	dsl	—	Natl 125	—	—
	67	dsl	—	Natl 110	—	—

U. S. OFFSHORE RIG LOCATOR

ALPHABETICAL LIST OF DRILLING CONTRACTORS

A

An-Son Offshore Drlg Co 1401 Carondelet Bldg New Orleans 12 La

B

Barnwell Offshore Inc 1748 Beck Bldg Shreveport La
Brewster-Bartle Drlg Co 707 Pere Marquette Bldg New Orleans La

C

Coral Drlg Co Inc 620 Saratoga Bldg New Orleans 12 La

D

Delta Marine Drlg Co 407 The Calif Co Bldg New Orleans 12 La

G

Glasscock Drlg Co 215 Shell Bldg New Orleans 12 La

K

Kerr-McGee Oil Ind Inc Box 711 Morgan City La

L

Liano Drlg Co 301 V & J Tower Bldg Midland Tex

M

Movible Offshore Co 743 San Jacinto Bldg Houston Tex

O

Ocean Drlg & Expl Co 300 Caribe Bldg New Orleans 19 La
Offshore-Submarex Inc Box 1135 Santa Barbara Cal

P

Penrod Drlg Co 1320 Mercantile Sec Bldg Dallas 1 Tex

R

Reading & Bates Offshore Drlg Co 610 Saratoga Bldg New Orleans 12 La
Rimrock Tidelands Inc Box 896 New Orleans La
Rowan Drlg Co Inc 600 Saratoga Bldg New Orleans 12 La

S

Salt Dome Prod Co 737 Tex Natl Bk Bldg Houston 2 Tex

Some abbreviations. To provide the greatest amount of information in a compact listing, it is necessary to employ some abbreviations. Manufacturers' names are indicated in the introduction of the RIG LOCATOR. Here is a list of abbreviations employed in the offshore section for operators and operator groups:

Operators

Bahama Cal—Bahama California Oil Company
Blk 27 Associates—Coastal Marine Drilling & Construction Company, Phillips Petroleum Company, Gulf Oil Corporation
CATC—Continental Oil Company, The Atlantic Refining Company, Tidewater Oil Company, and Cities Service Oil Company
Calco—The California Company.
Humble—The Humble Oil & Refining Company.
M-C-N—Magnolia Petroleum Company, Continental Oil Company, and Newmont Oil Company.
Phillips—Phillips Petroleum Company.
Shell—Shell Oil Company.
Sinclair—Sinclair Oil & Gas Company.
Std Cal—Standard Oil Company of California.
Superior—The Superior Oil Company of California.
Texaco—The Texas Company.

CALIFORNIA

SELF-CONTAINED PLATFORMS

Owner's Name	Rig, Barge Name or Number	Operator Drlg for	Offshore Location—(County)	Water Depth Ft	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Offshore-Submarex Inc	"PCS Exploit"	—	—	—	dsl engine	Howard-Turner	175	175	1,500
	"Labusca"	—	—	—	dsl engine	Howard-Turner	165	165	1,500
	"Sandab"	—	—	—	dsl engine	Howard-Turner	175	175	1,500

LOUISIANA

MOBILE DRILLING BARGES

Barnwell Offshore Inc	"Mister Cap"	Sinclair	Ship Shoal Blk 153	100	dsl-elec	Ideco E-2500	2500	2500	25,000
Coral Drlg Co	"Mr Arthur"	Calco	Bay Marchand Blk 2	50	dsl-elec	Brwstr N-12-A	1250	2500	20,000
Delta Marine Drlg Co	Rig 2 "Chris Zeppa"	Gulf	St Lse "PP" 192 West Delta Plaq Parish	22	dsl engine	Ideco Bg Gnt	1600	1950	15,000
Glasscock Drlg Co	Rig 12 "Mr Gus II"	CATC	Grand Isle Blk 69	126	dsl-elec	Natl 160-E	1950	3900	25,000
Kerr-McGee Oil Ind Inc	Rig 47	Standard of Tex	High Is Blk 140-L	70	dsl-elec	Emsco EDA-460	1250	1250	20,000
Movible Offshore Co	Rig 1	—	Terrebonne Bay	—	dsl engine	Natl 125	1250	1500	16,000/5"
	"Movible" 2	Mecom Pet	—	80	dsl-elec	Natl 1625	1250	2000	25,000/5"
	"Movible" 3	Mecom Pet	—	45	dsl-elec	Emsco EDA	1600	1700	20,000/5"

LOUISIANA MOBILE DRILLING BARGES — Continued

Owner's Name	Rig, Barge Name or Number	Operator Drlg for	Offshore Location—(County)	Water Depth Ft	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Ocean Drlg & Expl Co	"Margaret"	Shell	East Bay Blk 24	65	dsl-elec	Emsco EDES	1500	1000	20,000
	"St Louis"	Shell	East Bay Blk 24	30	dsl-elec	Emsco ECB	1200	1000	15,000
	"John Hayward"	Calco	Eugene Is Blk 93	30	dsl-elec	Emsco ECA	1200	1000	15,000
	"Mr Charlie"	—	Eugene Is Blk 90	40	dsl-elec	Emsco EDES	1500	1000	20,000
Penrod Drlg Co	Rig 50 "W O Woodward"	Hunt	Eugene Is Blk 117	49	dsl-elec	Emsco EDES	1250	2625	20,000
	Rig 51 "Jim Woodruff"	Calco	Main Pass Blk 41	30	dsl-elec	Emsco EDES	1250	2000	20,000
	Rig 52 "Petrel"	Placid	Eugene Is Blk 199	98	dsl-elec	Emsco EDES	1200	2000	20,000
Rimrock Tidelands Inc	"Rimtide"	Rimrock & Argo Pet	East Bay	35	dsl engine	Emsco A-1500	1500	2000	20,000
Rowan Drlg Co Inc	Bge 19	—	—	—	dsl-elec	M-CSCO U-1220-E	2250	2100	20,000

PLATFORM-TENDER DRILLING UNITS

An-Son Offshore Drlg Co	"Carl B Anderson"	—	—	—	dsl-elec	Emsco EDE	2550	2111	23,000
Delta Marine Drlg Co	Rig 1 "Joseph Zeppa"	—	—	—	dsl-elec	Emsco JB-1250	1600	1600	15,000
Llano Drlg Co	Rig 6 "Clayton G Dorn"	—	—	—	dsl engine	"Oilwell" 96	1800	2475	20,000
Reading & Bates Offshore Drlg Co	"J W Bates"	CATC	Eugene Is Blk 208	80	dsl engine	Natl 130	2000	2400	20,000
	"George M Reading"	CATC	Vermilion Blk 120	65	dsl engine	Natl 130	2000	3000	20,000
Rowan Drlg Co Inc	Rig 17	—	—	—	dsl engine	Natl 125	1305	2100	15,000
Salt Dome Prod Co	Rig 10 "Pelican"	Gulf	S Timbalier Blk 131	136	dsl engine	Beth 1013	1500	1500	15,000

SELF-CONTAINED PLATFORMS

Brewster-Bartle Drlg Co Inc	Rig 1	CATC	West Delta Blk 45-C	50	dsl engine	"Oilwell" 96	3300	3300	20,000
Rimrock Tidelands Inc	Rig 3	—	Morgan City	—	dsl-elec	Brwstr N-12-A	1300	2000	18,000
	Rig 15	—	Morgan City	—	dsl engine	Brwstr N-12-A	2000	2000	18,000

TEXAS

MOBILE DRILLING BARGES

Rimrock Tidelands Inc	Union Bge "A"	Union	Houston	75	dsl-elec	Ideco 2500	1600	2700	20,000

FOREIGN LOCATIONS

MOBILE DRILLING BARGES

Ocean Drlg & Expl Co	"El Dorado"	CIMA	Gulf of Campeche Mexico	70	dsl-elec	Emsco EDES	1500	1000	20,000
Reading & Bates Offshore Drlg Co	"C E Thornton"	—	Persian Gulf	—	dsl engine	Natl 110	1300	3000	16,000

PLATFORM-TENDER DRILLING UNITS

Reading & Bates Offshore Drlg Co	"J W Bates"	—	Persian Gulf	—	dsl engine	—	—	3000	—

U. S. Well Servicing Contractors

Alphabetical Listing

A

A-C Well Serv Box 356 Davenport Okla
Acme Well Serv Co Box 1331 Abilene Tex
Adams Prod Serv 2 Monte Vista Dr Bakersfield Calif
C N Adkisson Jr Box 875 McCamey Tex
Albright Well Serv Co Box 1192 Hobbs N M
Atlas Well Serv Inc Box 387 Ft Morgan Colo

B

B & B Oil Well Serv Box 6 Oil City La
B & B Well Serv Co Box 321 Salem Ill
B & R Well Serv 245 Catherine St Lockport La
B H B Superior Well Serv Inc Box 5 Denver City Tex
Baggett Drlg Co 4305 Univ Ave Wichita Falls Tex
Ballard Well Service Pettus Tex
Barnard Well Serv Box 617 Madison Kan
Basin Well Serv 2411 Rankin Hwy Midland Tex
Bateman & Whitsitt Inc Box 1956 Hobbs N M
Beal Drlg Co Box 124 Ada Okla
Beall Well Serv Co 571 San Jacinto Bldg Houston 2 Tex
Beckman Inc Box 1524 Muskogee Okla
Bice Drlg Co 1310 N Ellison Guymon Okla
Big Horn Drlg Co Inc 117 N Beech Casper Wyo
J W (Johnny) Birdwell Well Serv Box 201 Kamay Tex
Black Gold Well Serv Box 1427 OCS Lafayette La
Bolins Well Serv Box 512 Talco Tex
Booksh Well Serv Box 127 Grosse Tele La
Raymond K Brake Well Serv 638 W Broadway Centralia Ill
James R Brown Well Serv 1901 Florence St Kilgore Tex
Brownie Drlg Co P O Box 1417 Lake Charles La
Brownie's Oil Well Serv Co Inc Box 158 Andrews Tex

C

C & C Oilfield Serv Co Box 191 Oil City La
C & L Drlg & Serv Co Box 552 Ada Okla
Cactus Well Serv Co Box 222 Snyder Tex
Calhoun Well Serv Box 466 Aspermont Tex
California Prod Serv Inc 3252 Cherry Ave Long Beach 7 Cal
Camden Drlg Co Box 1418 Corpus Christi Tex
Capshaw Well Serv Co P O Box 1915 Casper Wyo
R L Carpenter Box 452 Sapulpa Okla
Carter-Jones Drlg Co Inc Box 1597 Kilgore Tex
Carter Well Serv Box 178 Pettus Tex
G H Chambers Well Serv Box 597 Ripley Okla
Chase Well Serv Inc Box 126 Chase Kans
M Cheairs Oil Well Serv Box 273 Norphlet Ark
Chesnut Well Serv Co Box 1491 Odessa Tex
Chris Well Serv Co Box 37 Lindsay Okla
Christian Inc Box 145 Chandler Okla
Christy Well Serv Co Box 516 Cortez Colo
Clarke & Dennis Well Serv Inc Chapin Bldg Medicine Lodge Kan
Clarke Oil Well Serv Co Box 2315 Hobbs N M
Cleaveland Well Serv Box 308 Luling Tex
Clinch Drlg Co Box 27 Hazlehurst Miss
Columbia Drlg Co 1207 C & I Life Bldg Houston 2 Tex
Copeland & Fuller Well Serv Box 237 Kenedy Tex
Copeland Well Serv Box 641 Russell Kan
Cramer Well Serv 503 N Creek Drumright Okla
Cron & Gracey Corp 1100 Houston Club Bldg Houston 24 Tex
C L Crotty Well Serv Box 66 Norphlet Ark

D

D & G Drlg Co Box 1477 Levelland Tex
D & L Drlg & Serv Box 121 Perryton Tex
Dapsco Inc Box 918 Laurel Miss
Deep Well Serv Co Inc 3218 Cheryl St Wichita Falls Tex
Devonian Well Serv Box 2821 Odessa Tex
Dollins Bro's Oil Well Serv Co Breckenridge Tex
Dyer Drlg Co Box 338 Casper Wyo

E

E & O Well Serv Co Inc Box 3066 Odessa Tex
Eagle Well Serv Box 270 Hoisington Kans
Eichler Well Serv Box 515 Jacksboro Tex
Dood Emerson Well Serv & Gen Contrg Box 228 Sulphur Springs Tex

F

Joe Flower Well Serv Co Box 14283 Houston 21 Tex
Fruge Well Service 1203 Center Vinton La

G

General Prod Serv Inc Box 442 Bakersfield Calif
Glenn Drlg Co 38 Kennedy Bldg Tulsa Okla
J P Graham Box 1307 Bay City Tex
Gulf Tide Drlg Co 450 Saratoga Bldg New Orleans La

H

Carl S Ham Inc Box 36 Andrews Tex
Ham & Reans Inc Box 1645 Kermit Tex
Dick Hamm Drlg Co Box 575 Grandfalls Tex
Dave Harlin Drlg Co 107 Bramfield Bldg Snyder Tex
Harris Drlg Co Inc Box 868 Eunice La
Harvey Well Serv Inc Box 94 Harvey La
John Haseman Inc 419 Wilson Bldg Corpus Christi Tex
Win Hawkins Drlg Co 373 San Jacinto Bldg Houston 2 Tex
John Heard & Co Inc Rm 4 Elm Oil Bldg Tulsa Okla
J E Hillier Box 67 Pleasanton Tex
Hoffman Oil Well Serv Co Box 1167 Seminole Tex
Ivan Holt Well Serv Box 401 Russell Kans
Hydraulic Pipe Pulling Co Box 391 Kilgore Tex

J

J & M Oil Well Serv Inc Box 1716-Oil Ctr Sta Lafayette La
Joe's Well Serv Box 612 Smackover Ark
Johnson Drlg & Serv Co Box 3 Magnolia Ark
F M Johnson Well Serv Box 613 Olney Tex

K

K B M Well Serv Inc Box 1338 Williston N D
Kay Serv Co Box 123 Alvin Tex
Keeney Well Serv Co Box 44 Pleasanton Tex
Kent Oil Field Serv Inc Box 749 El Dorado Kans
C E Knight & Co Box 1688 Snyder Tex

L

H J Lininger Box 37 Upper Sandusky Ohio
Locke Well Serv Box 312 Royalty Tex
Lodi Drlg & Serv Co Box 1669 Longview Tex
Longhorn Serv & Drlg Co Box 175 Wink Tex
Lunsford Drlg Co 505 Louisiana Bk Bldg Shreveport La

M

Mac Drlg Co Box 2972 Houston 1 Tex
Macrate Prod Co 3341 Cherry Ave Long Beach 7 Calif
Maddox Prod Co 2909 Junipero Ave Long Beach 8 Calif
Maxwell Well Serv Co Box 475 New London Tex
J F McAdams Box 1716 Hobbs N M
McAlister Well Serv Box 2214 Wichita Falls Tex
McCalman Drlg Co Inc Box 602 Homer La
McDaniel Well Serv Box 456 Seminole Okla
McDonald Well Serv Co Box 2062 Abilene Tex
Jack Mercer Well Serv Box 509 Nocona Tex
Mobile Well Serv Box 36 Cayuga Tex
Moose Well Serv Co Box 1325 Houston 1 Tex
C L Morris Well Serv Co Oil City La
Morrison Drlg Co Inc Box 583 Casper Wyo

N

Nichols & Freeman Well Serv Box 183 Grandfalls Tex

O

Oien Oil Corp Box 2235 Cut Bank Mont
Oil Well Serv Co 2405 Orange Ave Long Beach 6 Calif
O'Loughlin Well Serv Co Box 93 Perry Okla

P

Payne Bros Drlg Co Box 15 Lawrenceville Ill
Peerless Well Serv 117 E Seventh Odessa Tex

Dean Penick Casing Pulling Box 5174 Midland Tex
Penrod Drlg Co 1320 Mercantile Securities Bldg Dallas Tex
J E Perkins Inc Box 3143 Odessa Tex
Permian Serv Co Inc Box 1477 Levelland Tex
Permian Well Serv Inc Box 37 Wink Tex
Pico Drlg Co Box 512 Breckenridge Tex
Louis Pitcock Drlg Co Box 749 Graham Tex
Pool & Gerlich Drlg Co Box 1940 San Angelo Tex
Pool Well Serv Co Box 1940 San Angelo Tex
Potter Bros Box 1578 Kilgore Tex
W R (John) Potter Box 14 Kamay Tex
Prairie Drlg Co Box 2068 Casper Wyo
Price-Caudle Well Serv Inc Box 453 Seminole Okla
Producers Well Serv Inc Box 98 Boling Tex
T M Pruett Drlg Contr Box 303 Centralia Ill

Q

Quad Drlg Co Box 974 Ardmore Okla

R

R & R Well Serv Co — Colo Box 637 Rangely Colo
Rangely Well Serv Co Inc 321 C A Johnson Bldg Denver Colo
S S Reames Well Serv Box 387 Bloomfield N Mex

S

San Juan Drlg Co Box 728 Farmington N M
Savely Workover & Drlg Inc Box 407 Rosenberg Tex
Schaefer Well Serv Box 10 Victoria Tex
Shirer Well Serv Co Box 118 Hoisington Kans
Signal Oilfield Serv Inc 415 Petroleum Club Bldg Denver 2 Colo
Simmons Oilwell Serv 2432 Lemon Ave Signal Hill Calif
Sitton and Norton Drlg Co 406 Lubbock Natl Bk Bldg Lubbock Tex
Skinner & McDougal Drlg Co Box 8774 Oklahoma City Okla
Southwestern Inc Box 1116 Lovington N M
Spartan Well Serv 207 S & S Bldg Corpus Christi Tex
Spears Well Serv Inc Box 3187 Victoria Tex
J D Speer Healdton Okla
J D Sprecher Box 299 Casper Wyo
Spur Well Serv Co Box 1325 Houston 1 Tex
Steen Drlg Co 619 West Bldg Houston 2 Tex
Steitle Drlg Co 1312 Southwood Dr Alice Tex
Stewart's Casing Crew Box 14086 Houston 21 Tex
Stone Well Serv Box 386 Lolita Tex
Sunnyland Contracting Co Inc Box 388 Rayne La
Sutton Drlg Co Box 6446 San Antonio 9 Tex

T

Dudley Elrod Taylor 118 Fifth Ave SE Cut Bank Mont
Terminal Drlg & Prod Co 2975 Wilshire Blvd Suite 423 Los Angeles 5 Calif
Texas Drlg Co Box 183 Monahans Tex
Texas Swabbing Co Box 1571 Longview Tex
Texas Well Serv Co Box 191 Borger Tex
Texas Workover & Oilwell Serv Co Box 32 Liberty Tex
Beuford Thompson 2412 Clarinda Wichita Falls Tex
Thornbrugh Well Serv Co Box 541 Natchez Miss
J R Todd Co Inc Box 168 Odessa Tex
Twinoak Drlg Co 210 S Morton Okmulgee Okla

U

Universal Oilwell Serv Inc Box 1092 Snyder Tex

V

Varner Oil Well Serv Box 253 Royalty Tex
Veeder Supply & Dev Co Box 201 Cherryvale Kans
Carl Vickers Well Serv 1716 Wilson Tower Corpus Christi Tex

W

W L B Drlg Co 6635 Chocolate Bayou Rd Houston 21 Tex
W M & W Well Serv Co Box 931 Alice Tex
J H Wagner Drlg Co Box 751 El Dorado Kans
Weaver & Savage 1301 W. Armory Blackwell Okla
Dick Wegener Drlg Co 1820 First Natl Bldg Oklahoma City Okla
Well Serv Inc 1901 E Virginia Ave Victoria Tex
Wells Drlg Co 5282 Cherry Ave Long Beach 5 Calif
Art West Drlg Co 205 O'Michael Bldg Odessa Tex
Chet Whaley Well Serv Co Inc 6006 Milart St Houston 21 Tex
Wheless Drlg Co Box 368 Shreveport La
J C Williams Well Serv Co 603 S Arkansas Springhill La
Williamson Well Serv Inc Box 3828 Odessa Tex
Winnsboro Well Serv Box 102 Winnsboro Tex
Sam E Wood 546 Alvin Tex
Wyoming Well Serv Inc Box 350 Cody Wyo

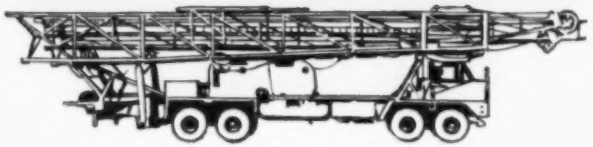
Y

Young's Well Serv Inc Box 1336 Seminole Okla

U. S. Contract Well Servicing or Pulling Units

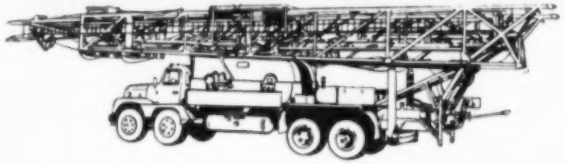
Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
ALABAMA							
Citronelle							
Dapsco Inc	9	Franks 658	Truck	—	15,000	15,000	Yes
	14	Franks 658	Truck	—	15,000	15,000	Yes
ARKANSAS							
Norphlet							
M Chesirs Oil Well Serv	2	Wilson Spr	Truck	1	—	5,000/2½"	Yes
	3	Wilson Master	Truck	1	—	3,500/2½"	Yes
	4	Cooper	Truck	1	—	10,000/2½"	No
	5	Vickers	Truck	1	—	2,500/2½"	No
C L Crotty Well Serv	10	Wilson Spr	Truck	—	8,000	—	No
	11	Wilson Mogul K-11	Truck	—	12,000	—	No
Smackover							
Joe's Well Serv	1	Cdwll H-1000	Truck	1	—	5,500/2" 5,000/2½"	No
	2	Franks 5000	Truck	1	—	8,500/2" 8,000/2½"	No
	3	Cooper	Truck	1	8,500	—	No
CALIFORNIA							
Bakersfield							
Adams Prod Serv	1	Wilson Spr Trcr	Trailer	2	11,600	11,600/2" 8,500/2½" 6,000/3"	No
General Prod Serv Inc	3	Hopper G	Truck	2	6,000	6,000/2" 4,000/2½" 3,000/3"	No
	7	Ideco 30	Trailer	2	10,000	10,000/2" 7,500/2½" 6,000/3"	No
	9	Hopper GTA	Truck	2	10,000	10,000/2" 7,500/2½" 6,000/3"	No
	11	Hopper GTA	Truck	2	13,000	15,000/2" 12,000/2½" 10,000/3"	No
Oil Well Serv Co	1-A	Ideco 40	Trailer	2	13,000	13,000/2½" 10,000/3"	Yes
	2-A	Ideco 40	Trailer	2	13,000	13,000/2½" 10,000/3"	Yes
	11	Ideco 30	Trailer	2	10,000	10,000/2½" 8,000/3"	Yes
	12	Cdwll	Trailer	2	5,000	5,000/2½" 4,000/3"	—
	15	Ideco 30	Trailer	2	13,000	13,000/2½" 8,000/3"	Yes
Castaic							
Calif Prod Serv Inc	H-3	Hopper G	Truck	2	10,000	10,000	Yes
	D-6	Emsco 500	Truck	2	15,000	15,000	Yes
	H-6	Hopper G	Truck	2	10,000	10,000	Yes
	M-7	Hopper 1G	Self Prop	2	8,000	8,000	No
	H-10	Wgnr Mrhse	Truck	2	10,000	10,000	Yes
	M-10	Hopper G	Self Prop	2	10,000	10,000	No
Kerman							
Oil Well Serv Co	4-A	Ideco 30	Trailer	2	10,000	10,000/2½" 7,000/3"	Yes
	41	Ideco 30	Trailer	2	10,000	10,000/2½" 7,000/3"	—
	57	Ideco 30	Trailer	2	13,000	13,000/2½" 8,000/3"	Yes
Long Beach							
Calif Prod Serv Inc	D-1	Hopper MTA	Trailer	2	15,000	15,000	Yes
	M-3	Hopper G	Trailer	2	10,000	10,000	Yes
	M-4	Hopper G	Trailer	2	10,000	10,000	Yes

FASTER PULLING
FASTER MOVING
FASTER SERVICE
LONGER LIFE



Explorer

New from wheels to crown. Power up to 400 HP. New main drum design for fast, safe pulling. New water and air cooling brake system. Models to 12,000 feet.

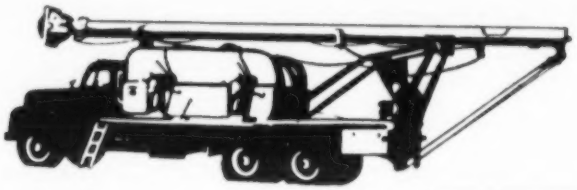


Rocket

A singularly efficient and economical line with single or tandem front end. Three models with capacities ranging to 12,000 feet.

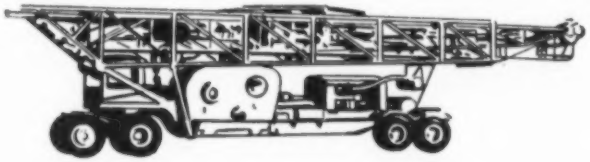
A FRANKS MODEL FOR EVERY WEL

L SERVICING AND WORKOVER NEED



Cruiser

The most widely accepted servicing unit in the field. Eight models, single or double pole masts. All balanced capacities to 12,000 feet.



Clipper

Self-propelled integrated units that head into location instead of backing in. Three models with servicing and workover capacities to 14,000 feet.

Franks gives you a unit to match every job in the field and then backs it up with 24-hour parts and field service.
You can depend on FRANKS.

WELL SERVICING AND DRILLING UNITS
FRANKS
DIVISION OF
PAMPA, TEXAS
CABOT SHOPS INC.

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Trans-ported	No. of Drums	Estimated Capacity Swab-bing	Pulling	Can Unit Also Drill?
	H-5	Hopper G	Truck	2	10,000	10,000	Yes
	M-6	Hopper G	Trailer	2	10,000	10,000	Yes
	M-8	Wgnr Mrhse	Trailer	2	10,000	10,000	Yes
	H-9	Hopper 1G	Truck	2	8,000	8,000	Yes
	H 13	Wgnr Mrhse	Truck	2	10,000	10,000	Yes
Macrate Prod Co	1	Ideco H-30	Trailer	2	10,000	12,000/2"	Yes
						10,000/2½"	
						8,000/3"	
	4	Wgnr Mrhse	Trailer	2	10,000	12,000/2"	No
						10,000/2½"	
						8,000/3"	
	6	Wgnr Mrhse	Trailer	2	10,000	12,000/2"	No
						10,000/2½"	
						8,000/3"	
	8	Wgnr Mrhse	Trailer	2	12,000	14,000/2"	Yes
						12,000/2½"	
						10,000/3"	
Oil Well Serv Co	2	Wisn Mogul	Truck	1	—	12,000/2½"	Yes
						6,500/3"	
	3	Ideco	Truck	2	13,000	13,000/2½"	Yes
						7,000/3"	
	5	Ideco	Trailer	2	5,000	5,000/2½"	Yes
						4,000/3"	
	6	Crdwll	Truck	2	10,000	7,000/2½"	—
						6,500/3"	
	7	Ideco 30	Trailer	2	13,000	13,000/2½"	Yes
						7,000/3"	
	8	Wisn	Truck	2	6,500	6,500/2½"	—
						4,500/3"	
	9	Ideco 30	Trailer	2	13,000	13,000/2½"	Yes
						7,000/3"	
	10	Ideco 30	Trailer	2	10,000	10,000/2½"	Yes
						7,000/3"	
	14	Ideco 30	Trailer	2	13,000	13,000/2½"	Yes
						7,000/3"	
Signal Hill							
Maddox Prod Co	1	Hopper	Truck	2	8,000	12,000/2"	Yes
						9,000/2½"	
						7,000/3"	
	2	Wisn Spr	Trailer	2	10,000	17,000/2"	Yes
						13,000/2½"	
						10,000/3"	
	4	Wisn Mogul	Trailer	2	13,000	17,000/2"	Yes
						13,000/2½"	
						10,000/3"	
Simmons Oilwell Serv	1	Ideco H-30-AD	Truck	2	11,000	10,000/2½"	No
	2	Hopper IG-TA	Self-Prop	2	10,000	8,000/2½"	No
Ventura							
Calif Prod Serv Inc	D-2	Hopper MTA	Trailer	2	15,000	15,000	Yes
	D-3	Hopper MTA	Trailer	2	15,000	15,000	Yes
	D-4	Hopper MTA	Trailer	2	15,000	15,000	Yes
	D-5	"Oilwell" 66	Truck	2	15,000	15,000	Yes
	M-5	Ideco H-30	Trailer	2	10,000	10,000	Yes
	M 9	Hopper G	Self Prop	2	10,000	10,000	No
Terminal Drlg & Prod Co	10	Ideco Rambler	Truck	2	13,000	11,500/2½"	Yes
	16	Wisn	Truck	2	15,000	15,000/2½"	No
Wilmington							
Moore Prod Serv	1	Crdwll	Trailer	2	6,000	8,000/2"	Yes
						6,000/2½"	
						5,000/3"	
	2	Hopper Hoist	Truck	2	10,000	10,000/2"	Yes
						10,000/2½"	
						9,000/3"	
Terminal Drlg & Prod Co	11	Frnks 65-44	Truck	2	12,000	10,745/2½"	No
	13	Ideco H-30	Truck	2	11,000	9,420/2½"	No
	15	Ideco	Truck	2	12,000	10,600/2½"	Yes
	19	Ideco H-30	Truck	2	13,500	13,400/2½"	Yes
	22	Crdwll RL	Truck	2	10,000	10,000/2½"	Yes
	23	Crdwll HL	Truck	2	7,200	5,000/2½"	No
		COLORADO					
Cortez							
Christy Well Serv Co	4	Crdwll K-203	Truck	—	12,000	12,000	No
	5	Crdwll AH	Truck	—	10,000	7,500	No
	11	Crdwll K-201	Truck	—	12,000	12,000	Yes
	12	Crdwll A-150	Truck	—	10,000	7,500	No

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Trans-ported	No. of Drums	Estimated Capacity Swab-bing	Pulling	Can Unit Also Drill?
Ft. Morgan							
Atlas Well Serv Inc	1	Frnks Rocket	Truck	2	8,000	8,500	Yes
	2	Frnks Explr	Self-Prop	1	—	6,500	Yes
Rangley							
R & R Well Serv Co-Colo.	1	Frnks 658-TD	Truck	1	13,500	16,000/2"	Yes
						12,500/2½"	
						10,000/3"	
	2	Frnks 658-TD	Truck	1	13,500	16,000/2"	Yes
						12,500/2½"	
						10,000/3"	
	3	Frnks 658-TD	Truck	1	13,500	16,000/2"	Yes
						12,500/2½"	
						10,000/3"	
	4	Frnks 658-TD	Truck	1	13,500	16,000/2"	Yes
						12,500/2½"	
						10,000/3"	
	5	Frnks 658-TD	Truck	1	13,500	—	Yes
	6	Frnks 658-TD	Truck	1	13,500	16,000/2"	Yes
						12,500/2½"	
						10,000/3"	
	7	Frnks 658-TD	Truck	1	13,500	16,000/2"	Yes
						12,500/2½"	
						10,000/3"	
	8	Frnks 65 TM	Truck	1	13,500	—	Yes
	9	Frnks 658-TD	Skid Mt'd	1	13,500	16,000/2"	No
						12,500/2½"	
						10,000/3"	
Rangely Well Serv Co Inc	1	Frnks 137-TD	Truck	—	15,000	15,000	Yes
Sterling							
Signal Oilfield Serv Inc	2	Frnks 658/44	Truck	2	10,000	—	Yes
		ILLINOIS					
Centralia							
Raymond K Brake Well Serv	1	Vickers	Truck	—	3,000	4,500	No
	2	Cooper	Truck	—	3,000	4,500	No
	3	Wilson	Truck	—	1,500	2,000	No
	4	Cooper	Truck	2	3,300	5,000	Yes
	5	Wilson	Truck	2	5,000	8,000	Yes
West Salem							
B & B Well Serv Co	1	Crdwll	Truck	1	—	4,600/2"	No
						4,600/2½"	
	2	Crdwll	Truck	1	—	4,600/2"	No
						4,600/2½"	
	4	Crdwll	Truck	1	—	4,600/2"	No
						4,600/2½"	
	5	—	Truck	2	3,500	4,600	No
	6	—	Truck	2	3,500	4,600	No
		KANSAS					
Chase							
Chase Well Serv Inc	1	Frnks 4000TM	Truck	1	—	5,000/2"	—
						4,500/2½"	
						3,600/3"	
	2	Frnks TM-44	Truck	1	—	6,000/2"	—
						5,500/2½"	
						4,500/3"	
Hoisington							
Eagle Well Serv Co	—	Frnks Cruiser	Truck	—	4,500	5,000	No
Shirer Well Serv Co	1	Crdwll H	Truck	1	—	5,000	No
	2	Frnks	Truck	1	—	5,000	No
	3	Crdwll H	Truck	2	5,000	5,000	No
Madison							
Barnard Well Serv	6	Cooper W	Truck	—	—	3,000	No
	7	Cooper W	Truck	—	—	3,000	No
	9	Cooper W	Truck	—	—	3,000	No
	12	Cooper W	Truck	—	3,000	3,000	Yes
	13	Cooper W	Truck	—	—	3,000	No
Medicine Lodge							
Clarke & Dennis Well Serv Inc	14	Crdwll AH	Truck	2	6,000	5,500	No
	15	Frnks	Truck	1	8,000	7,000	No
	16	Frnks	Truck	2	8,000	7,000	Yes
Plainville							
Chase Well Serv Inc	3	Frnks TM-65	Truck	1	—	8,000/2"	—
						7,000/2½"	
						6,000/3"	
	4	Frnks TM-44	Truck	1	—	6,000/2"	—
						5,500/2½"	
						4,500/3"	
Pratt							
Chase Well Serv Inc	6	Frnks DTM	Truck	2	6,500	6,000/2"	No
						5,500/2½"	
						4,500/3"	

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
Russell							
Copeland Well Serv	1	Frnks 5000	Truck	—	—	4,000	No
Ivan Holt Well Serv	1	Crdwll KS	Truck	—	—	6,000	No
	2	Crdwll HS	Truck	—	—	5,000	No
	3	Crdwll KS	Truck	—	—	6,000	No
LOUISIANA							
Empire							
Bayou Well Works Inc	Bge 1	Wlsn	barge	1	12,500	—	—
Grosse Tete							
Booksh Well Serv	1	Cooper Skytop	Truck	—	13,500	15,000	Yes
	2	Cooper Skytop	Truck	—	13,500	15,000	Yes
	3	Cooper	Truck	—	13,500	—	No
Harvey							
Harvey Well Serv Inc	1	Frnks 5000	Bge Mt'd	—	—	16,000/2"	Yes
Lafayette							
Black Gold Well Serv	1	Crdwll H	Skid Mt'd	1	Concentric Tubing		No
	2	Wlsn	Trailer	1	Concentric Tubing		No
	3	Cooper	Skid Mt d	1	Concentric Tubing		No
J & M Oil Well Serv Inc	1	Wlsn Gnt	Skid Mt'd	—	14,000	14,000	Yes
	2	Wlsn Gnt	Skid Mt'd	—	14,000	14,000	Yes
Lake Charles							
Brownie Drlg Co	1	M-CSCO U-34	Skid Mt'd	—	—	18,000	Yes
	2	Wlsn Spr 38	Truck	—	—	15,000	Yes
Lockport							
B & R Well Serv	1	Frnks 65-TD	Truck	—	—	90,000	Yes
	2	Frnks 65-TD	Truck	—	—	90,000	Yes
	3	Frnks 658	Truck	—	—	125 000	Yes
New Iberia							
Bayou Well Works Inc	51	Wlsn	Truck	1	12,500	—	—
	58	Wlsn	Truck	1	12,500	—	—
	63	Wlsn	Truck	1	12,500	—	—
	70	Brwstr	Truck	1	15,000	—	—
	87	Cooper	Truck	1	12,500	—	—
Oil City							
B & B Oil Well Serv	1	Wilson	Truck	2	2,500	2,750/2" 2,500/2½"	No
	2	Crdwll	Truck	1	2,500	2,000/2" 2,000/2½"	No
C & C Oil Field Serv Co	1	Wlsn Sr	Truck	2	5,000	5,000/2" 3,000/2½" 2,500/3"	No
	2	Wlsn Sr	Truck	2	5,000	5,000/2" 4,000/2½" 3,000/3"	No
	3	Wlsn Sr	Truck	1	—	5,000/2" 4,000/2½" 3,000/3"	No
	4	Wlsn Sr	Truck	1	—	5,000"2" 4,000/2½" 3,000/3"	No
	5	Wlsn Sr	Truck	1	—	5,000/2" 4,000/2½" 3,000/3"	No
	6	Wlsn Sr	Truck	1	—	5,000/2" 4,000/2½" 3,000/3"	No
Springhill							
J C Williams Well Serv Co	1	Wlsn Sr	Truck	1	—	3,100/2½"	No
	2	Wlsn Spr	Truck	1	6,000	—	No
	4	Wlsn Spr	Truck	1	—	7,500/2½"	Yes
	5	Wlsn Spr	Truck	2	10,000	7,500/2½"	Yes
	7	Wlsn Spr	Truck	1	10,000	—	No
	8	Wlsn Spr	Truck	1	—	8,500/2½"	No
Vinton							
Fruge Well Serv	2	Wlsn Spr	Trailer	—	12,000	—	No
	3	Wlsn Spr	Truck	1	12,000	—	No
	4	Wlsn Mogul	Skid Mt'd	—	—	12,000	No
	5	Cooper 42	Truck	1	—	12,000	No
	6	Cooper 42	Truck	—	—	12,000/2½"	No
	7	Cooper 42	Truck	—	—	12,000	No
	8	Cooper UM	Skid Mt'd	—	—	10,000	No
MISSISSIPPI							
Baxterville							
Dapsco Inc	4	Wlsn Spr	Truck	—	15,000	15,000	Yes
	5-B	Wlsn Spr	Truck	—	11,000	6,500	No
	6	Beth S-40	Truck	—	15,000	15,000	Yes
	10	Frnks 658	Truck	—	15,000	15,000	Yes
	12	Frnks 658	Truck	—	15,000	15,000	Yes
Heidelberg							
Dapsco Inc	7	Frnks 658	Truck	—	15,000	15,000	Yes
Laurel							
Dapsco Inc	6-B	Wlsn Mogul	Truck	—	11,000	6,000	No
	7-B	Wlsn Spr	Truck	—	11,000	6,000	No
	8	Frnks 658	Truck	—	15,000	15,000	Yes
	9-B	Wlsn Spr	Truck	—	11,000	6,000	No
	11	Frnks 658	Truck	—	15,000	15,000	Yes
Natchez							
Thornbrugh Well Serv Co	15	Wlsn Spr	Truck	1	—	8,500/2" 7,500/2½"	—
	16	Wlsn Spr	Truck	1	—	8,500/2" 7,500/2½"	—
	18	Cooper 38	Truck	1	10,000	10,000/2" 9,000/2½"	—
	20	Wlsn Spr	Truck	1	—	12,000/2" 10,000/2½"	Yes
	23	Ideco	Truck	1	12,500	—	—
	24	Wlsn Spr	Truck	1	—	12,500/2" 11,500/2½"	Yes
Yellow Creek							
Dapsco Inc	5	Wlsn Spr 38	Truck	—	15,000	15,000	Yes
MONTANA							
Cut Bank							
Dudley Elrod Taylor	3	Crdwll AH	Truck	2	7,000	5,000/2½"	—
	4	Frnks 26	Truck	1	—	3,200/2½"	No
Glendive							
K B M Well Serv Inc	3	Crdwll H	Truck	1	7,500	6,500/2" 5,000/2½"	No
	4	Wlsn Mogul 42	Truck	1	15,000	15,000/2" 12,000/2½"	No
	8	Wlsn Spr 38	Truck	2	13,500	15,000/2" 12,000/2½"	No
Signal Oilfield Serv Inc	10	Frnks 658/65	Truck	2	12,000	—	Yes
	14	Frnks 658/65	Truck	2	10,000	—	No
NEW MEXICO							
Bloomfield							
S S Reames Well Serv	3	Crdwll RL	Skid Mt'd	—	10,000	10,000	Yes
	4	Crdwll RL	Skid Mt'd	—	10,000	10,000	Yes
	6	Crdwll M-250	Self-Prop	—	11,000	13,500	Yes
	7	Crdwll M-250	Self-Prop	—	11,000	13,500	Yes
Eunice							
Clarke Oil Well Serv Co	5	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
	7	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
	9	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
Farmington							
Calif Prod Serv Inc	M-1	Hopper G	Trailer	2	10,000	10,000	Yes
	M-2	Hopper G	Trailer	2	10,000	10,000	Yes
	H-4	Hopper 1G	Truck	2	8,000	8,000	Yes
Signal Oilfield Serv Inc	6	Frnks 65/44	Truck	2	8,000	—	Yes
Hobbs							
Albright Well Serv Co	4	Frnks 65	Truck	1	11,000	10,000/2"	Yes
	5	Frnks 65	Truck	1	11,000	10,000/2"	No
	12	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½"	Yes
	17	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½" 9,000/3"	Yes
	23	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½" 9,000/3"	Yes
	27	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½" 9,000/3"	Yes
	34	Frnks 658	Truck	2	13,000	13,000/2" 12,000/2½" 9,000/3"	Yes
Bateman & Whitsitt Inc	1	Crdwll K	Truck	1	11,000	—	No
	10	Hopper GXFA	Truck	2	15,000	15,000/2" 12,500/2½" 9,000/3"	No
	15	Frnks 658	Truck	2	15,000	15,000/2" 12,500/2½" 9,000/3"	No
	20	Frnks 658	Truck	2	15,000	15,000/2" 12,500/2½" 9,000/3"	No

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
	25	Frnks 7000	Truck	1	—	15,000/2" 12,500/2½" 9,000/3"	No
	30	Frnks 658	Truck	2	13,500	15,000/2" 12,500/2½" 9,000/3"	No
	35	Frnks 658	Truck	2	13,500	15,000/2" 12,500/2½" 9,000/3"	No
	40	Frnks 658	Truck	2	13,500	15,000/2" 12,500/2½" 9,000/3"	No
	45	Hopper GXFA	Truck	2	15,000	15,000/2" 12,500/2½" 9,000/3"	No
	50	Hopper GXFA	Truck	2	15,000	15,000/2" 12,500/2½" 9,000/3"	No
Clarke Oil Well Serv Co	1	Frnks 658	Truck	2	14,000	14,000/2" 12,000/2½" 10,000/3"	No
	2	Frnks 658	Truck	2	12,000	14,000/2" 12,000/2½" 10,000/3"	No
	3	Frnks 658	Truck	2	14,000	14,000/2" 12,000/2½" 10,000/3"	No
	4	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
	6	Frnks 658	Truck	2	12,000	14,000/2" 12,000/2½" 10,000/3"	No
	10	Frnks 658	Truck	2	13,000	14,000/2" 12,000/2½" 10,000/3"	No
J F McAdams	38	Frnks 658	Truck	—	13,000	15,000	No
	39	Frnks 658	Truck	—	13,000	15,000	No
	43	Wisn Spr	Truck	—	8,000	8,000	No
	47	Hooper TWCB	Truck	—	13,000	15,000	No
	64	Frnks 658	Truck	—	13,000	15,000	No
	65	Frnks 658	Truck	—	13,000	15,000	No
Lovington							
Southwestern Inc	1	Frnks 658	Truck	2	12,500	12,500	Yes
	2	Frnks 658	Truck	2	12,500	12,500	Yes
	3	Frnks 658	Truck	1	12,500	12,500	Yes
	4	Wisn Mogul	Truck	—	15,000	15,000	Yes
	8	Frnks 658	Truck	2	12,500	12,500	Yes
	9	Crdwll KM-250	Self-Prop	—	18,000	18,000	Yes
NORTH DAKOTA							
Keene							
K B M Well Serv Inc	5	Wisn Mogul 42	Truck	1	15,000	15,000/2" 12,000/2½"	No
	6	Wisn Spr 38	Truck	2	13,500	15,000/2" 12,000/2½"	No
	7	Wisn Spr 38	Truck	2	13,500	15,000/2" 12,000/2½"	No
	9	Wisn Spr 38	Truck	2	13,500	15,000/2" 12,000/2½"	No
Tioga							
K B M Well Serv Inc	1	Frnks 658 DTM2	Truck	2	13,500	15,000/2" 12,000, 2½"	No
	2	Frnks 658 DTM2	Truck	2	13,500	15,000/2" 12,000/2½"	No
	10	Wisn Spr 38	Truck	2	13,500	15,000/2" 12,000/2½"	No
	11	Wisn Spr 38	Truck	2	13,500	15,000/2" 12,000/2½"	No
OKLAHOMA							
Ada							
Beal Drlg Co	1	Wlkr-Nr 32	Trailer	—	4,000	—	Yes
	1	Wlkr-Nr S-43	Trailer	—	4,000	—	Yes
	1	Crdwll RL	Skid Mt'd	—	7,000	—	Yes
C & L Drlg & Serv Co	1	Wichtex	Truck	—	4,000	4,000	No
	2	Wichtex	Truck	—	4,000	4,000	No
	3	Cooper	Truck	—	3,200	3,200	Yes
	5	Wichtex	Truck	—	5,500	5,500	No
	6	Wilson	Truck	—	5,500	5,500	No
Blackwell							
Weaver & Savage	DD-1	Frnks 44	Truck	2	10,000	10,000/2" 8,000/2½" 6,000/3"	No
	R&T-1	Crdwll H	Truck	1	—	7,000/2" 5,000/2½" 4,500/3"	No
	DD-2	Frnks 65	Truck	2	12,000	12,000/2" 10,000/2½" 7,000/3"	No
	R&T-2	Crdwll H	Truck	1	—	7,000/2" 5,000/2½" 4,500/3"	No
	DD-3	Frnks 44	Truck	2	10,000	10,000/2" 8,000/2½" 6,000/3"	No
Davenport							
A-C Well Serv	1	Crdwll RL	Skid Mt'd	—	8,500	—	Yes
	2	Frnks E Tex Sp	Truck	—	3,000	—	No
	3	Frnks 44	Truck	—	6,000	—	Yes
	4	Frnks Spr	Truck	—	6,000	—	No
Drumright							
Cramer Well Serv	1	Frnks 65	Truck	2	6,000	7,500/2" 5,000/3"	No
	2	Frnks 5000	Truck	2	6,000	7,500/2" 5,000/3"	No
	3	Frnks 65	Truck	1	—	10,000/2"	No
	4	Frnks 65	Truck	1	—	7,500/2"	No
	5	Frnks 65	Truck	2	6,000	7,500/2" 5,000/3"	No
	6	Frnks 65	Truck	2	6,000	7,500/2" 5,000/3"	No
Lindsey							
Chris Well Serv Co Ltd	3	Frnks 658 DTM	Truck	—	12,000	12,000	No
	4	Frnks 658 DTM	Truck	—	12,000	12,000	No
	5	Frnks 658 DTM	Truck	—	12,000	12,000	No
	7	Frnks Rocket	Truck	—	12,000	12,000	Yes
	11	Frnks 658 DTM	Truck	—	12,000	12,000	No
	12	Ideco Rambler	Truck	—	12,000	12,000	Yes
	14	Frnks Rocket	Truck	—	12,000	12,000	Yes
Christian Inc	101	Frnks 44DTM	Truck	2	5,500	8,500/2" 6,500/2½"	No
	107	Frnks 44DTM	Truck	2	6,000	8,500/2" 6,500/2½"	Yes
	126	Frnks 44DTM	Truck	2	6,000	8,500/2" 6,500/2½"	Yes
Okemah							
Skinner & McDougal Drlg Co	1	Allis Chmrs	Truck	1	4,500	—	No
Pawhuska							
Kent Oil Field Serv Inc	1	Cooper W	Truck	—	3,500	3,500	No
	2	Cooper 34-26-26	Truck	—	3,500	3,500	Yes
	5	Cooper W	Truck	—	3,500	3,500	Yes
	7	Cooper W	Truck	—	3,500	3,500	No
	8	Cooper W	Truck	—	3,500	3,500	No
	10	Cooper W	Truck	—	—	3,500	No
	11	Cooper W	Truck	—	—	3,500	No
	12	Cooper W	Truck	—	3,500	3,500	No
Perry							
O'Loughlin Well Serv Co	101	Frnks 65	Truck	2	7,000	7,000/2" 7,000/2½" 6,000/3"	No
	102	Frnks 65	Truck	1	7,000	7,000/2" 7,000/2½" 6,000/3"	No
Ripley							
G H Chambers Well Serv	1	Wichtex C-65	Truck	—	7,500	7,000	No
	2	Wichtex C-65	Truck	—	7,500	7,000	No
	3	Wichtex C-65	Truck	—	7,500	7,000	No
Sapulpa							
R L Carpenter	1	Cooper W	Truck	1	3,000	3,000/2" 2,500/2½" 2,000/3"	No
Seminole							
McDaniel Well Serv	1	Frnks 65-DTM	Truck	2	6,500	10,000/2" 6,500/2½"	No
	2	Frnks 65-DTM	Truck	2	6,500	10,000/2" 6,500/2½"	No
	3	Frnks 44-DTM	Truck	2	5,500	10,000/2" 6,500/2½"	No
Price-Caudle Well Serv Inc	1	Frnks 65	Truck	1	—	10,000/2" 10,000/2½" 10,000/3"	No
	2	Frnks 44	Truck	2	8,000	10,000/2" 10,000/2½" 10,000/3"	Yes
	3	Frnks 44	Truck	2	8,000	10,000/2" 10,000/2½" 10,000/3"	Yes

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
Young's Well Serv Inc	1	Frnks	Truck	—	—	6,000	No
	2	Frnks	Truck	—	—	6,000	No
	3	Frnks	Truck	—	—	7,500	No
	4	Frnks	Truck	—	—	7,500	No
Webb City							
Barnard Well Serv	10	Cooper P 32-26	Truck	—	4,000	5,000	No
	15	Cooper E-42	Truck	—	—	6,000	No
	16	Cooper M-42	Truck	—	5,000	4,000	No
TEXAS							
Abilene							
McDonald Well Serv Co	1	Frnks 44-DTM	Truck	2	8,500	9,000/2" 6,000/2½"	Yes
	2	Frnks 44-DTM	Truck	2	8,500	10,000/2" 7,000/2½"	Yes
	3	Wlsn Spr 38	Truck	2	8,500	10,000/2" 7,000/2½"	Yes
	4	Wichtex C-60	Truck	2	5,500	4,500/2" 3,000/2½"	No
Alice							
Steitle Drlg Co	1	Wlsn Mogul	Trailer	2	12,000	16,000/2½"	Yes
W M & W Well Serv Co	1	Wlsn Spr	Truck	2	7,000	7,000/2" 6,000/2½" 5,000/3"	Yes
	2	Allis Chmrs	Truck	2	8,000	10,000/2" 10,000/2½"	Yes
	3	Wlsn Spr	Truck	2	6,500	6,000/2" 5,000/2½"	Yes
	5	Wlsn Spr	Truck	2	7,500	6,500/2"	Yes
	7	Wlsn 38	Truck	2	8,500	8,800/2" 7,500/2½"	Yes
	9	Wlsn Spr	Truck	2	8,500	8,588/2" 7,000/2½"	Yes
Alvin							
Kay Serv Co	5	Wlsn Mogul	Truck	1	11,000	—	—
Sam E Wood	1	Ideco H-20	Truck	2	—	11,000/2" 9,000/2½"	Yes
	2	Wlsn Gnt	Trailer	1	—	14,000/2" 13,000/2½"	Yes
Andrews							
Brownie's Oil Well Serv Co Inc	4	Frnks 658-DTM2	Truck	—	13,000	13,500	No
	5	Frnks 658-DTM2	Truck	—	13,000	13,500	No
	8	Frnks 658-DTM2	Truck	—	13,000	13,500	No
	9	Frnks 658-DTM2	Truck	—	13,000	13,500	No
	10	Frnks 658-DTM2	Truck	—	13,000	13,500	No
	11	Frnks 658-DTM2	Truck	—	13,000	13,500	No
	12	Frnks Rocket	Truck	—	13,500	15,000	No
	13	Frnks Rocket	Truck	—	13,500	15,000	No
	14	Frnks Rocket	Truck	—	13,500	15,000	No
Calhoun Well Serv	1	Wlsn Spr	Truck	2	9,000	8,000/2" 7,000/2½" 5,000/3"	Yes
	2	Wlsn Spr	Truck	2	9,000	8,000/2" 7,000/2½" 5,000/3"	Yes
	3	Cooper	Truck	2	8,000	7,000/2" 6,000/2½" 4,000/2"	—
D & G Drlg Co	5	Cooper 420-36	Truck	—	14,000	16,000	Yes
Carl S Ham Inc	1	Crdwll KM-250	Truck	—	15,000	15,000	Yes
	2	Crdwll K-251	Truck	—	15,000	15,000	Yes
	3	Crdwll K-200	Truck	—	13,500	13,500	Yes
	4	Crdwll K-200	Truck	—	13,500	13,500	Yes
	5	Crdwll K-200	Truck	—	13,500	13,500	Yes
	6	Crdwll K-200	Truck	—	13,500	13,500	Yes
	7	Crdwll K-200	Truck	—	13,500	13,500	Yes
	8	Crdwll K-200	Truck	—	13,500	13,500	Yes
Permian Serv Co Inc	2	Crdwll H	Truck	—	6,500	6,500	No
	5	Cooper 119	Truck	2	13,000	13,000	Yes
	10	Wlsn Spr 38	Truck	—	12,000	12,000	No
	12	Wlsn Spr 38	Truck	—	12,000	12,000	No
	14	Wlsn Spr 38	Truck	—	12,000	12,000	No
Williamson Well Serv Inc	18	Frnks 658	Truck	2	13,500	13,500/2½"	No
	20	Frnks 658	Truck	2	13,500	13,500/2½"	No
	21	Frnks 658	Truck	2	13,500	13,500/2½"	No
	23	Frnks 658	Truck	2	13,500	13,500/2½"	No
	26	Frnks 658	Truck	2	13,500	13,500/2½"	No
	33	Frnks 658	Truck	2	13,500	13,500/2½"	No
	37	Frnks 658	Truck	2	13,500	13,500/2½"	No
Bay City							
J P Graham	12	Wlsn Spr	Truck	1	9,000	—	No
	18	Wlsn Spr	Truck	1	9,000	—	No
	26	Wlsn Spr	Truck	1	10,000	—	No
Baytown							
Beall Well Serv Co	3	Crdwll K	Truck	—	6,500	10,000	Yes
Big Lake							
Pool Well Serv Co	1	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	6	Wlsn Spr	Truck	1	10,000	—	No
	10	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	11	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	19	Wlsn Spr	Truck	1	10,000	—	—
	25	Wlsn Spr 38	Trailer	2	14,000	12,000/2½"	No
	31	Frnks	Truck	2	12,000	14,000/2½"	No
Boling							
Producers Well Serv Inc	4	Cooper	Truck	2	3,500	3,500	Yes
	5	Wlsn Spr	Truck	—	9,000	—	No
	6	Cooper T-38	Truck	—	—	8,000	Yes
	7	Skytop	Self-Prop	—	—	12,000	Yes
Breckenridge							
Dollins Bro's Oil Well Serv Co	1	Wlsn Master	Truck	—	10,000	10,000	Yes
	1	Wichtex	Truck	—	6,000	8,000	No
	2	Wlsn Master	Truck	—	10,000	10,000	Yes
	2	Wichtex	Truck	—	6,000	8,000	No
	3	Wlsn Master	Truck	—	10,000	10,000	Yes
Bryson							
Eichler Well Serv	4	Wichtex C-60	Truck	2	5,000	5,000/2"	No
	5	Wichtex C-65	Truck	2	6,000	6,000/2"	No
Cayuga							
Mobile Well Serv	1	Wlsn Spr	Truck	1	—	8,000/2" 5,000/2½"	No
	5	Wlsn Spr	Truck	1	—	8,000/2" 5,000/2½"	No
	8	Wlsn Spr	Truck	1	—	8,000/2" 5,000/2½"	No
Conroe							
Spur Well Serv Co	2	Frnks 65-TD	Truck	1	—	8,000/2½"	Yes
Corpus Christi							
Spartan Well Serv	1	Crdwll KL	Truck	1	6,000	10,000/2" 8,000/2½" 6,500/3"	—
	2	Wichtex	Truck	2	5,000	6,000	Yes
Crane							
J R Todd Co Inc	4	Crdwll AL	Truck	2	9,000	8,000/2" 6,000/2½" 4,500/3"	No
	6	Crdwll K-200	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	Yes
	7	Crdwll K-200	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	Yes
	8	Crdwll K-200	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	Yes
	9	Crdwll K-200	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	Yes
Williamson Well Serv Inc	15	Frnks 658	Truck	2	13,500	13,500/2½"	No
	19	Frnks 658	Truck	2	13,500	13,500/2½"	No
	35	Frnks 658	Truck	2	13,500	13,500/2½"	No
Denver City							
B H B Superior Well Serv Inc	1	Cooper A142-42	Truck	2	13,000	14,000/2" 12,500/2½" 11,000/3"	Yes
	4	Cooper TR38-38	Truck	2	9,000	8,000/2" 7,000/2½" 6,000/3"	Yes
	5	Cooper T420-48	Truck	2	14,000	16,000/2" 13,500/2½" 12,000/3"	Yes
El Campo							
Kay Serv Co	4	Frnks	Truck	1	7,500	—	—
Graham							
Louis Pitcock Drlg Co	21	Wichtex Spdr	Trailer	—	6,000	6,000	Yes
Grandfalls							
Nichols & Freeman Well Serv	4	Wlsn Sr	Truck	2	4,500	5,000/2" 4,000/2½" 2,500/3"	No
	6	Wlsn Sr	Truck	2	4,500	4,000/2" 3,500/2½" 2,500/3"	No
	14	Wlsn Sr	Truck	2	5,000	5,000/2" 4,000/2½" 3,300/3"	No

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
	15	Wlsn Spr	Truck	1	—	8,000/2" 5,000/2½" 4,000/3"	No
	22	Wlsn Spr	Truck	2	11,000	10,000/2" 10,000/2½" 7,000/3"	No
Greggton							
Texas Swabbing Co	1	Wlsn Spr	Truck	1	—	8,000/2" 7,500/2½"	Yes
	2	Wlsn Spr	Truck	1	—	8,000/2" 7,500/2½"	Yes
	3	Wlsn Spr	Truck	1	—	8,000/2" 7,500/2½"	Yes
	4	Wlsn Spr	Truck	1	—	8,000/2" 7,500/2½"	Yes
	5	Frnks	Truck	1	10,000	—	No
Hardin							
Beall Well Serv Co	2	Natl T-8	Truck	—	—	10,000	No
High Island							
Kay Serv Co	1	Wlsn Mogul	Truck	1	11,000	—	—
Holiday							
Baggett Drlg Co	1	Wlkr-Nr 37	Trailer	3	7,000	9,000	Yes
	2	Wlkr-Nr 27	Truck	2	7,000	8,000	Yes
	3	Wlkr-Nr 38	Trailer	3	7,000	8,000	Yes
	4	Wlkr-Nr 27	Truck	2	7,000	8,000	Yes
Houston							
Joe Flower Well Serv Co	2	Wlsn Spr 38	Truck	1	—	11,000/2" 9,000/2½"	Yes
	3	Natl T	Truck	1	—	10,000/2" 8,000/2½"	Yes
	5	Frnks 65D	Truck	1	—	11,000/2" 9,000/2½"	Yes
Moose Well Serv Co	1	Frnks 65-TD	Truck	1	—	8,000/2½"	Yes
Spur Well Serv Co	1	Frnks 65-TD	Truck	1	—	8,000/2½"	Yes
Stewart's Casing Crew	1	Cooper E	Truck	1	—	8,000/2" 6,500/2½"	Yes
	3	Cooper 420	Truck	1	—	11,000/2" 9,000/2½"	Yes
	5	Cooper 420	Truck	1	—	11,000/2" 9,000/2½"	Yes
	6	Cooper 420	Truck	1	—	11,000/2" 9,000/2½"	Yes
	7	Cooper TR-42	Truck	1	—	10,000/2" 8,000/2½"	No
	8	Cooper AP-138	Truck	1	—	10,000/2" 8,000/2½"	No
	9	Frnks	Skid Mt'd	1	—	10,000/2" 8,000/2½"	Yes
Jackson							
Stone Well Serv	1	Frnks	Truck	—	6,080	—	No
	2	Wlsn	Truck	—	10,000	—	No
	2	Frnks	Truck	—	—	4,200	Yes
	3	Frnks	Truck	—	—	4,200	Yes
	4	Cooper	Truck	—	—	4,200	Yes
	5	Crdwll	Truck	—	—	4,200	Yes
Kamey							
J W (Johnny) Birdwell Well Serv	2	Wlsn Master	Truck	2	5,500	5,500/2"	Yes
	3	Wichtex C-65	Truck	2	6,500	6,500/2"	Yes
	4	Wlkr-Nr	Truck	1	4,500	4,500/2"	No
	5	Wichtex C-65	Truck	2	6,500	6,500/2"	Yes
W R (John) Potter	1	Wlsn Spr	Truck	1	—	6,000/2" 5,500/2½"	No
	3	Wlsn Master	Truck	2	5,500	6,700/2" 6,000/2½"	Yes
Kenedy							
Copeland & Fuller Well Serv	1	Wlsn Spr 38	Truck	2	8,000	8,500/2" 7,500/2½"	Yes
	2	Cooper A-38	Truck	2	8,000	10,000/2" 8,500/2½"	Yes
Kermit							
Ham & Reans Inc	1	Crdwll K-200	Truck	—	13,500	13,500	Yes
	2	Crdwll K-200	Truck	—	13,500	13,500	Yes
	3	Crdwll K-200	Truck	—	13,500	13,500	Yes
	4	Crdwll K-200	Truck	—	13,500	13,500	Yes
	5	Crdwll K-200	Truck	—	13,500	13,500	Yes
Kilgore							
Carter-Jones Drlg Co Inc	1	Wlsn	Truck	1	7,000	5,000/2" 4,000/2½" 2,500/3"	No
	2	Wlsn	Truck	1	10,000	10,000/2" 8,000/2½" 5,000/3"	Yes
	3	Frnks	Truck	2	13,000	13,000/2" 10,000/2½" 7,000/3"	Yes
Hydraulic Pipe Pulling Co	3	Wlsn Spr	Skid Mt'd	—	—	10,000	Yes
	5	Wlsn Spr	Skid Mt'd	—	—	10,000	Yes
Potter Bros	1	Wlsn Spr	Truck	1	—	7,500/2" 6,500/2½" 5,500/3"	Yes
	2	Crdwll	Truck	1	4,000	7,500/2" 6,500/2½" 5,500/3"	Yes
	4	Wlsn Spr	Truck	1	—	5,000/2" 4,500/2½" 4,000/3"	No
Loveland							
D & G Drlg Co	1	Frnks 658	Truck	—	12,000	12,000	Yes
Permian Serv Co Inc	1	Frnks 658	Truck	2	12,000	12,000	Yes
	4	Wlsn Spr	Truck	—	9,000	9,000	No
	11	Wlsn Spr 38	Truck	—	12,000	12,000	No
	15	Wlsn Spr	Truck	—	9,000	9,000	No
Liberty							
Texas Workover & Oilwell Serv Co	3	Wlsn Spr	Truck	1	—	10,000/2" 8,000/2½"	No
	4	Wlsn Spr	Truck	1	10,000	—	No
	5	Wlsn Spr	Truck	1	10,000	—	No
Lodi							
Lodi Drlg & Serv Co	1	Wlsn Spr	Truck	1	7,500	—	No
	2	Wlsn Spr	Truck	1	—	7,000/2½"	Yes
	4	Wlsn Spr	Truck	1	9,000	—	No
	5	Wlsn Spr 38	Truck	1	—	9,000/2½"	Yes
	7	Wlsn Spr 38	Truck	1	—	9,000/2½"	Yes
Lolita							
Stone Well Serv	1	Frnks	Truck	—	—	4,200	Yes
Luling							
Cleaveland Well Serv	1	Frnks 33	Truck	1	—	5,000/2" 3,300/2½" 2,600/3"	No
	2	Crdwll AH	Truck	2	5,000	5,000/2" 4,000/2½" 3,000/3"	Yes
Mobank							
Mobile Well Serv	6	Wlsn Spr	Truck	1	—	8,000/2" 5,000/2½"	No
Malakoff							
Kay Serv Co	6	Wlsn Sr	Truck	1	5,500	—	—
Midland							
Basin Well Serv Inc	32	Hopper DD	Trailer	—	12,500	12,500	No
	37	Hopper Derrick	Truck	—	12,500	12,500	Yes
	38	Hopper	Truck	—	12,500	12,500	Yes
	44	Hopper DD	Trailer	—	12,500	12,500	No
	46	Hopper DD	Trailer	—	12,500	12,500	No
Dean Penick Casing Pulling	1	Wlsn Spr	Truck	1	—	10,000/2" 10,000/2½" 10,000/3"	No
Pool Well Serv Co	7	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	12	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	14	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	15	Wlsn Spr 38	Trailer	2	12,000	14,000/2½"	No
	17	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	No
	22	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	No
	24	Wlsn Spr	Truck	1	10,000	—	No
	27	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	Yes
	30	Wlsn Spr 38	Truck	2	12,000	14,000/2½"	No
Williamson Well Serv Inc	27	Frnks 658	Truck	2	13,500	13,500/2½"	No
	28	Frnks 658	Truck	2	13,500	13,500/2½"	No
	30	Frnks 658	Truck	2	13,500	13,500/2½"	No
	31	Frnks 658	Truck	2	13,500	13,500/2½"	No
New London							
Maxwell Well Serv Co	1	Wlsn Spr	Truck	1	—	10,000/2" 8,500/2½" 6,500/3"	No
	2	Wlsn Spr	Truck	1	—	10,000/2" 8,500/2½" 6,500/3"	Yes
	3	Wlsn Spr	Truck	1	—	10,000/2" 8,500/2½" 6,500/3"	No
	4	Wlsn Spr	Truck	1	—	10,000/2" 8,500/2½" 6,500/3"	—
	5	Wlsn Spr	Truck	1	9,500	—	—

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity: Swabbing	Estimated Capacity: Pulling	Can Unit Also Drill?
Nocona							
Jack Mercer Well Serv	2	Wlsn Sr	Truck	1	—	3,000/2" 2,500/2½" 2,500/3"	No
	7	Wichtex C-65	Truck	2	7,500	7,500/2" 7,500/2½" 6,500/3"	Yes
	8	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	15	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	18	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	20	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
	33	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
Novice							
Pool Well Serv Co	9	Wlsn Sr	Truck	2	6,500	5,000/2½"	No
Odessa							
Chesnut Well Serv Co	1	Frnks 658	Truck	—	13,500	13,500	No
	2	Frnks 658	Truck	—	13,500	13,500	No
	3	Frnks 658	Truck	—	13,500	13,500	No
	4	Frnks 658	Truck	—	13,500	13,500	No
	5	Frnks 658	Truck	—	13,500	13,500	No
	6	Frnks 658	Truck	—	13,500	13,500	No
Devonian Well Serv	6	Frnks 658	Truck	2	14,000	15,000/2" 14,000/2½" 11,000/3"	Yes
E & O Well Serv Co Inc	1	Crdwll S	Truck	1	13,500	—	No
Peerless Well Serv	7	Cooper T-42-42	Truck	—	15,000	12,000	Yes
	9	Wlsn Spr	Truck	—	10,000	8,000	No
	10	Cooper T-44-10	Truck	—	15,000	14,000	Yes
J R Todd Co Inc	1	Frnks 658DTM	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	No
	2	Frnks 658DTM	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	No
	3	Frnks 658DTM	Truck	2	13,000	13,000/2" 12,000/2½" 10,000/3"	No
Williamson Well Serv Inc	3	Frnks 658	Truck	2	13,500	13,500/2½"	No
	7	Frnks 658	Truck	2	13,500	13,500/2½"	No
	11	Frnks 658	Truck	2	13,500	13,500/2½"	No
	13	Frnks 658	Truck	2	13,500	13,500/2½"	No
	17	Frnks 658	Truck	2	13,500	13,500/2½"	No
	24	Frnks 658	Truck	2	13,500	13,500/2½"	No
	32	Frnks 658	Truck	2	13,500	13,500/2½"	No
	34	Frnks 658	Truck	2	13,500	13,500/2½"	No
	36	Frnks 658	Truck	2	13,500	13,500/2½"	No
Palestine							
Mobile Well Serv	9	Wlsn Spr	Truck	1	9,000	—	No
Perryton							
D & L Drlg & Serv	1	Crdwll K-200	Truck	2	13,000	10,000/2½"	No
	3	Frnks 658	Truck	1	12,000	10,000/2½"	No
	4	Crdwll AH	Truck	2	11,000	10,000/2½"	No
Pool Well Serv Co	18	Wlsn Mogul 42	Trailer	2	14,000	14,000/2½"	No
	20	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
Pettus							
Ballard Well Serv	6	Wlsn Spr 38	Trailer	2	12,000	15,000	Yes
	7	Hopper Hoist	Truck	2	10,000	10,000	Yes
	8	Hopper IGXTA	Truck	2	10,000	10,000	Yes
Carter Well Serv	1	Wlsn Spr	Truck	2	9,500	9,500/2" 8,000/2½" 6,500/3"	Yes
	2	Wlsn Spr	Truck	2	9,500	9,500/2" 8,000/2½" 6,500/3"	Yes
	3	Wlsn Spr	Truck	2	9,500	9,500/2" 8,000/2½" 6,500/3"	Yes
Plains							
B H B Superior Well Serv Inc	3	Cooper A142-42	Truck	2	13,000	14,000/2" 12,500/2½" 11,000/3"	Yes
Pleasanton							
Keeney Well Serv Co	1	Crdwll	Truck	2	7,500	—	Yes
	2	Wlsn Sr	Truck	2	6,000	—	Yes
	3	Wlsn Spr	Truck	1	8,000	—	Yes
Rosenberg							
Savely Workover & Drlg Inc	4	Frnks 658	Self-Prop	1	—	13,500/2" 12,000/2½" 7,500/3"	Yes
	5	Frnks 658	Self-Prop	1	—	13,500/2" 12,000/2½" 7,500/3"	Yes
Royalty							
Locke Well Serv	1	Wlsn Spr	Truck	2	8,000	8,000/2" 8,000/2½" 8,000/3"	Yes
	2	Crdwll K	Truck	1	—	10,000/2" 7,000/2½" 5,000/3"	No
	3	Wlsn Spr	Truck	2	10,000	10,000/2" 7,000/2½" 5,000/3"	Yes
Varner Oil Well Serv	1	Wlkr-Nr P-25	Truck	2	6,000	6,000/2" 5,000/2½" 3,000/3"	No
	2	Wlsn	Truck	2	—	3,000/2" 2,500/2½"	No
	3	Wlsn	Truck	2	4,000	5,000/2" 4,000/2½" 3,000/3"	No
	4	Wlkr-Nr C-23	Truck	2	3,000	5,000/2" 4,000/2½" 3,000/3"	Yes
Rule							
Acme Well Serv Co	1	Wichtex C-65	Truck	—	7,500	8,000	Yes
	3	Wichtex C-65	Truck	—	7,500	8,000	Yes
San Angelo							
Pool Well Serv Co	4	Wlsn Spr	Truck	1	10,000	—	No
	16	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
	21	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	26	Wlsn Spr	Truck	2	6,500	5,000/2½"	No
Seminole							
B H B Superior Well Serv Inc	2	Cooper A142-42	Truck	2	13,000	14,000/2" 12,500/2½" 11,000/3"	Yes
Hoffman Oil Well Serv Co	1	Wlsn Spr 38	Truck	2	—	8,000/2½"	Yes
	2	Wlsn Mogul	Truck	2	—	10,000/2½"	Yes
	3	Frnks 658	Truck	2	13,000	13,000/2½" 11,000/3"	Yes
	4	Frnks 658	Truck	2	13,000	13,000/2½" 11,000/3"	Yes
	5	Frnks 658	Truck	2	13,000	13,000/2½" 11,000/3"	Yes
	6	Frnks 658	Truck	2	13,000	13,000/2½" 11,000/3"	Yes
	7	Frnks 658	Truck	2	13,000	13,000/2½" 11,000/3"	Yes
Snyder							
Cactus Well Serv Co	1	Wlsn Spr	Truck	1	10,000	—	No
	3	Wlsn Spr 38	Truck	2	10,000	12,000/2" 10,000/2½" 8,000/3"	Yes
	7	Frnks 658DTM	Truck	2	12,500	14,000/2" 12,000/2½" 10,000/3"	Yes
Universal Oilwell Serv Inc	136	Frnks 65 DTM2	Truck	2	11,000	10,000/2" 8,000/2½" 6,000/3"	Yes
	146	Frnks 658	Truck	2	12,500	15,000/2" 12,000/2½" 10,000/3"	Yes
	182	Frnks 658/65	Truck	2	11,000	15,000/2" 12,000/2½" 10,000/3"	Yes
	204	Frnks 658/65	Truck	2	11,000	15,000/2" 12,000/2½" 10,000/3"	Yes
	218	Frnks 658/65	Truck	2	11,000	15,000/2" 12,000/2½" 10,000/3"	Yes
Sulphur Bluff							
Dood Emerson Well Serv & Gen Contg	1	Cooper E-60	Truck	1	5,000	10,000/2" 7,500/2½"	Yes

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
Sulphur Springs							
Dood Emerson Well Serv & Gen Contg	2	Wlsn Spr	Truck	1	5,000	10,000/2" 7,500/2½"	Yes
Sweetwater							
Pool Well Serv Co	3	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	5	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
Talco							
Bolins Well Serv	—	Wlsn Spr	Truck	—	8,000	7,000	Yes
Tucker							
Mobile Well Serv	4	Wlsn Spr	Truck	1	—	8,000/2" 5,000/2½"	No
Victoria							
Schaefer Well Serv	1	Skytop	Trailer	—	8,000	9,500	Yes
	2	Skytop	Trailer	—	14,000	14,000	Yes
Spears Well Serv Inc	1	Wlsn Spr	Truck	2	8,000	8,500/2" 6,500/2½"	Yes
	2	Wlsn Spr	Truck	2	8,000	8,500/2" 6,500/2½"	Yes
	3	Wlsn Spr	Truck	2	8,000	8,500/2" 6,500/2½"	Yes
	4	Wlsn Spr	Truck	1	8,000	—	—
	5	Skytop Wltrwt	Truck	2	8,000	10,000/2" 8,000/2½"	Yes
	6	Skytop Wltrwt	Truck	2	8,000	10,000/2" 8,000/2½"	Yes
Well Serv Inc	1	Frnks TM65	Truck	1	—	8,500/2" 6,500/2½"	Yes
	2	Frnks TM65	Truck	1	—	8,500/2" 6,500/2½"	Yes
	3	Frnks TM65	Truck	1	—	8,500/2" 6,500/2½"	Yes
Waskom							
James R Brown Well Serv	1	Wlsn Spr	Truck	1	10,000	—	No
	2	Wlsn Spr	Truck	1	—	12,000/2" 11,500/2½" 6,000/3"	Yes
	3	Wlsn Spr 38	Truck	1	—	13,000/2" 13,000/2½" 8,000/3"	Yes
Whitesboro							
Jack Mercer Well Serv	6	Wichtex E-75	Truck	2	9,500	9,500/2" 9,500/2½" 8,000/3"	Yes
Wichita Falls							
Deep Well Serv Co Inc	1	Wichtex C-65	Truck	2	6,200	6,500/2" 5,500/2½"	No
McAlister Well Serv	7	Wlsn Spr	Truck	2	7,500	7,500/2" 6,500/2½"	No
	10	Wlsn Spr	Truck	2	7,500	7,500/2" 6,500/2½"	No
	20	C-25	Truck	2	7,500	7,500/2" 6,500/2½"	Yes
	42	Wichtex	Truck	2	5,000	5,000/2" 3,600/2½"	No
	45	Wichtex	Truck	1	—	5,000/2" 3,600/2½"	No
Ramey Well Serv	1	Wichtex E-65	Truck	2	8,000	14,000/2" 12,000/2½" 10,000/3"	Yes
	2	Wichtex E-75	Truck	2	8,000	14,000/2" 12,000/2½" 10,000/3"	Yes
Windthorst							
Beuford Thompson	2	Wichtex C-65	Truck	2	6,500	6,500/2"	Yes
Wink							
Permian Well Serv Inc	2	Wlsn Gnt	Truck	1	—	12,000/2" 10,000/2½" 8,000/3"	No
	3	Wlsn Spr	Truck	2	10,000	10,000/2" 8,500/2½" 6,500/3"	No
	6	Wlsn Spr	Truck	2	10,000	10,000/2" 8,500/2½" 6,500/3"	No
Winnsboro							
Winnsboro Well Serv Co	F-1	Frnks Rocket	Truck	2	6,500	8,500/2" 7,200/2½"	Yes
	F-2	Frnks Rocket	Truck	2	6,500	8,500/2" 7,200/2½"	Yes
	W-4	Wlsn Spr	Truck	1	8,500	—	—
	F-5	Frnks Spr	Truck	1	—	8,500/2" 7,200/2½"	Yes
	F-6	Frnks 44	Truck	1	—	6,000/2" 5,000/2½"	Yes
Winters							
Pool Well Serv Co	2	Wlsn Spr	Truck	2	10,000	8,000/2½"	No
	8	Wlsn Sr	Truck	2	6,500	5,000/2½"	No
	23	Wlsn Spr	Truck	1	10,000	—	No
	28	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	No
WYOMING							
Casper							
Capshaw Well Serv Co	1	Crdwll	Truck	2	10,000	10,000/2½"	No
	2	Wilson	Self-Prop	2	10,000	10,000/2½"	No
Cody							
Wyoming Well Serv Inc	23	Ideco 50-60	Truck	1	8,000	7,000/2" 6,000/2½" 4,000/3"	Yes
	24	Frnks 65/44	Truck	2	10,000	10,000/2" 8,000/2½" 6,000/3"	Yes
	25	Crdwll	Truck	2	12,000	10,000/2½"	Yes
	30	Crdwll KS	Truck	1	8,000	9,000/2" 7,500/2½" 5,000/3"	Yes
Linch							
Wyoming Well Serv Inc	22	Crdwll KS	Truck	1	9,000	8,000/2" 7,000/2½" 6,000/3"	Yes
	29	White L W	Truck	1	10,000	—	No

U. S. Cable Tool Servicing Rigs

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
COLORADO						
Sterling County						
Signal Oilfield Serv Inc	4	dsl	125	2	— 7500	Crdwll RL
	5	dsl	125	2	— 7500	Crdwll RL
	11	gas	125	2	— 7500	Crdwll RL
ILLINOIS						
Lawrenceville County						
Payne Bros Drlg Co	1	dsl	150	3	3000 4000	B Erie 36-L
	2	dsl	150	3	3000 4000	B Erie 36-L
	3	dsl	150	3	3000 4000	B Erie 36-L
KANSAS						
Arkansas City						
J H Wagner Drlg Co	2	gas-LPG	145	—	3500 4500	B Erie 36-L
El Dorado						
J H Wagner Drlg Co	3	gas-LPG	145	—	3500 4500	B Erie 36-L
Great Bend						
Signal Oilfield Serv Inc	1	dsl	125	2	— 7500	Crdwll RL
	7	gas	125	3	— 5000	Wlkr-Nr
	9	dsl	125	2	— 7500	Crdwll RL
Montgomery County						
Veeder Sup & Dev Co	BE 2	dsl	120	3	3500 4500	B Erie
MONTANA						
Cut Bank						
Dudley Elrod Taylor	1	gas-gaso	140	2	— 4000	Wlsn Gnt Truck Mounted
NEW MEXICO						
Farmington						
Signal Oilfield Serv Inc	12	gas	125	2	— 7500	Crdwll RL
	13	gas	125	2	— 7500	Crdwll RL
Jal						
Art West Drlg Co	3	LPG	145	2	— 5500	Crdwll RL
OHIO						
Upper Sandusky						
H J Lininger	2	dsl	175	—	3500 —	L C Moore
Wyandot County						
H J Lininger	1	gas-gaso	78	—	2500 —	Beth Cyclone
	3	gas-gaso	65	—	1800 —	Beth Cyclone
OKLAHOMA						
Blackwell						
Weaver & Savage	S-1	gas	145	2	— 7500	Crdwll RL
	S-3	gas	145	2	— 5000	Wlsn Mogul
	S-4	gas	145	3	— 5000	Wlkr-Nr 43
	S-5	gas	145	3	— 5000	Wlkr-Nr 43

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
Guymon						
Bice Drlg Co	1	dsl	185	2 3000	4500	Wichtex E-90
	2	btne	210	4 7000	10,000	B Erie
Okemah						
Skinner & McDougal Drlg Co	1	gaso-btne	145	2 4000	6500	Crdwll
	2	gaso-btne	145	3 4000	5500	Wlkr-Nr
	3	gaso-btne	145	2 4000	5500	Crdwll
Okmulgee						
Smallwood & Son Drlg Co	2	btne	—	3 3500	5600	B Erie 36-L
Shidler						
Signal Oilfield Serv Inc	3	gas	125	2 —	7500	Crdwll RL
	8	gas	125	3 —	5000	Wlkr-Nr
TEXAS						
Grandfalls County						
Dick Hamm Drlg Co	1	btne	145	3 4500	7000	Wlkr-Nr S-33
	2	btne	140	3 —	3500	Wlkr-Nr C-33
	3	—	—	— 4000	4000	B Erie 36-L
Holiday						
Baggett Drlg Co	1	LPG	200	3 7000	8000	Wlkr-Nr 37
	2	LPG	175	2 —	7000	Wlkr-Nr 27
	3	LPG	200	3 7000	8000	Wlkr-Nr 34
	4	LPG	175	2 —	7000	Wlkr-Nr 27
Kermit						
Art West Drlg Co	7	LPG	145	2 —	8000	Crdwll RL
McCamey						
C N Adkisson Jr	1	LPG	100	3 2500	3000	B Erie 28-L
Odessa						
Art West Drlg Co	5	LPG	185	3 —	8500	Crdwll RL
	9	LPG	185	2 —	9000	Wlsn Gnt
	10	dsl	125	2 —	8000	Crdwll RL
Olney						
F M Johnson Well Serv	1	LPG	135	3 —	2000	Johnson Sp 30
	2	LPG	135	3 —	3500	Clark 30
	3	LPG	135	3 —	3500	Clark 30
	4	LPG	145	3 —	4500	Clark 30 Sp
	5	LPG	145	3 —	4500	Clark 20 Sp
Stinnett						
Texas Well Serv Co	2	btne	145	2 5000	5000	B Erie 36-L
	3	btne	145	2 5000	5000	B Erie 36-L
	4	btne	140	2 5000	5000	Wichtex
Wichita Falls						
Deep Well Serv Co Inc	2	LPG	140	2 —	6500	Wichtex C-65
McAlister Well Serv	32	LPG	185	3 —	7000	Wlkr-Nr C-34
Wickett						
Art West Drlg Co	6	gas	145	2 —	8000	Crdwll RL
	8	gas	145	2 —	8000	Crdwll RL
WYOMING						
Casper						
Prairie Drlg Co	2	gas	190	3 —	10,000	Crdwll RS
Glenrock						
Morrison Drlg Co Inc(Wyo)	2	btne	185	2 5500	8000	Crdwll
	3	btne	185	2 5500	8000	Crdwll
Rock Springs						
Morrison Drlg Co Inc(Wyo)	1	btne	145	2 4500	6000	Crdwll

U. S. Rotary Workover Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Workover Depth, Ft
ARKANSAS						
Lewisville						
McCalman Drlg Co Inc	1	dsl	—	Brwstr N-4	300	8,000
Morphiet						
M Cheairs Oil Well Serv	1	gaso	90	Wlsn Spr	90	5,000
CALIFORNIA						
Bakersfield						
General Prod Serv Inc	10	dsl	300	Hopper GTA	300	7,500/2⅞
	12	dsl	300	Hopper M	380	12,000/2⅞
Oil Well Serv Co	1-A	dsl	500	Ideco 40	300	13,000
	2-A	dsl	400	Ideco 40	300	13,000
	11	LPG	400	Ideco 30	280	8,000
	15	LPG	400	Ideco 30	300	10,000
Kerman						
Oil Well Serv Co	4-A	dsl	300	Ideco 30	300	8,000
	57	dsl	300	Ideco 35 Drive In	300	12,000
Long Beach						
Macrate Prod Co	2	dsl	190	Ideco H-30-AD	190	6,000
	7	gas-LPG	300	Wgnr-Mrhse 15-40	250	8,000
	8	dsl	300	Wgnr-Mrhse 35-40	330	10,000
Oil Well Serv Co	9	LPG	400	Ideco 30	300	10,000
	10	dsl	300	Ideco 30	300	8,000
Wells Drlg Co	2	dsl	325	Mobile Blitz 622	350	7,500
Ventura						
Terminal Drlg & Prod Co	18	dsl	500	Ideco U-525D	600	16,000
Wilmington						
Terminal Drlg & Prod Co	12	gas-LPG	320	Ideco H-30D	190	9,000
	14	gas-LPG	140	Ideco H-25D	125	3,500
	17	dsl	500	Wlsn Mogul	350	12,000
ILLINOIS						
Centralia						
T M Pruett Drlg Contr	1	dsl	300	M-CSCO U-15	300	8,000
KANSAS						
Reno						
Veeder Supply & Dev Co	E	dsl	270	Frnks 658	270	8,000
Sheridan						
Veeder Supply & Dev Co	D	dsl	280	Natl T-25	300	4,500
LOUISIANA						
Buras						
Clinch Drlg Co	Bge 1	dsl	—	Emsco GA-350	426	8,500
	Bge 1	dsl	—	Emsco GA-350	426	12,000
Caddo Parish						
Lunsford Drlg Co	1	LPG	185	Brwstr N-3	145	4,000
Claiborne Parish						
Wheless Drlg Co	1	gas-btne	510	Brwstr N-45	450	7,500
Desoto Parish						
Johnson Drlg & Serv Co	1	dsl	340	Beth Breeze	200	10,000
Eunice						
Harris Drlg Co Inc	3	gas	200	Crdwll RL	200	12,000/2"
	5	gas	155	Crdwll K	155	10,000/2"
Harvey						
Cron & Gracey Corp	3	dsl	—	TIW CT-5	520	16,000
Lafayette						
Wm Hawkins Drlg Co	2	gas-btne	300	M-CSCO U-15	485	16,000
La Salle						
Penrod Drlg Co	2	gas-btne	570	Brwstr N-45	550	7,000
Lincoln Parish						
Johnson Drlg & Serv Co	2	dsl	500	Beth Twister	300	12,500
Rayne						
Sunnyland Contg Co Inc	8	gas	422	Crdwll D	422	13,000/2"
Springhill						
J C Williams Well Serv Co	9	dsl	220	Wlsn Mogul	220	1,200
Venice						
Gulf Tide Drlg Co	1	dsl	600	Wlsn Spr Gnt	600	15,000
MISSISSIPPI						
Natchez						
Thornbrugh Well Serv Co	9	LPG	125	Wlsn Mogul	125	10,000
	21	dsl	225	Wlsn Gnt	200	12,000
MONTANA						
Glendive						
Signal Oilfield Serv Inc	10	dsl	250	Frnks 658/65	250	12,000
Powder River						
Oien Oil Corp	3	dsl	500	Natl T-20	280	5,000
NEW MEXICO						
Farmington						
Signal Oilfield Serv Inc	6	LPG	150	Frnks 65/44	200	8,000
Lea						
Pico Drlg Co	4	gas-btne	180	Wlsn Mogul	300	4,000
OKLAHOMA						
Ardmore						
Quad Drlg Co	1	gaso-btne	1000	Frnks Gnt Clipper	275	15,000
	2	btne	150	Crdwll KL	125	6,500
Carter						
J D Speer	1	dsl	104	Wlsn Spr	104	2,000/3½"
Grady						
Dick Wegener Drlg Co	4	gas-dsl	1900	Natl 130	1900	22,000
Oklahoma City						
Beckman Inc	3	gas	150	MIW P-42	200	10,000
	5	gas	180	MIW P-42	200	10,000
	12	gas	150	MIW P-42	200	10,000
	17	gas	150	MIW P-42	200	10,000
	18	gas	150	MIW P-42	200	10,000
	19	—	180	MIW P-42	200	10,000
Twinoak Drlg Co	1	dsl	190	Frnks	190	3,000
Osage County						
John Heard & Co Inc	1	gas-LPG	240	Brwstr N-4	212	3,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Workover Depth, Ft
TEXAS						
Alice						
Steitle Drlg Co	1	dsl	311	Wlsn Mogul	302	16,000
W M & W Well Serv Co	9	dsl	300	Wlsn Spr	150	4,000
Barbours Cut, Harris County						
Columbia Drlg Co	Bge 1	dsl	800	"Oilwell" 76	750	18,000
Bexar						
J E Hillier	3	dsl	800	Crdwll KM-250	400	15,000
Carrizo Spring						
Sutton Drlg Co	9	—	—	—	—	4,000
Cayuga						
Mobile Well Serv	2	LPG	185	Wlsn Spr	200	9,000
	3	LPG	185	TIW	300	10,000
	10	LPG	185	Frnks 65-44 DTD	200	9,000
Charlotte						
Sutton Drlg Co	8	gas-gaso	—	Wlsn	125	5,000
Conroe						
Spur Well Serv Co	2	gas-gaso	100	Frnks 65-TD	180	8,000
Corpus Christi						
Carl Vickers Well Serv	1	gas-gaso-btne	308	Crdwll Tririg	308	12,000
	4	gas-gaso-btne	160	Crdwll K-200	160	8,000
Groggton						
Texas Swabbing Co	1	LPG	—	Wlsn Spr	80	8,000
	2	LPG	—	Wlsn Spr	80	8,000
	3	LPG	—	Wlsn Spr	80	8,000
	4	LPG	—	Wlsn Spr	80	8,000
Houston						
Joe Flower Well Serv Co	1	gas-btne	400	Natl T-20	300	13,000
Mac Drlg Co	5	gas-gaso-btne	275	Beth S-45	450	15,000
Spur Well Serv Co	1	gas-gaso	100	Frnks 65-TD	180	8,000
	3	gas-LPG-dsl	250	Frnks 137	580	12,000
Stewart's Casing Crew	1	gas-gaso	—	Cooper E	60	8,000/2"
	3	gas-gaso	—	Cooper 420	145	11,000/2"
	5	gas-gaso	—	Cooper 420	145	11,000/2"
	6	gas-gaso	—	Cooper 420	145	11,000/2"
	9	gas-gaso	—	—	145	10,000/2"
W L B Drlg Co	1	gas-gaso-btne	370	Brwstr N-35	197	10,000
Chet Whaley Well Serv Co Inc	1	gas-gaso-btne	225	Wlsn Gnt	225	8,000
	2	gas-gaso-btne	225	Wlsn Gnt	275	8,000
Jasper						
Steen Drlg Co	3	gas-btne	700	Emsco J-750	1000	11,500
Kilgore						
Carter-Jones Drlg Co Inc	7	btne	370	Wlsn Gnt	225	12,000
	11	btne	370	Brwstr N-4	185	12,000
Liberty						
Texas Workover & Oilwell Serv Co	2	gas-LPG	475	Brwstr N-4	450	14,000
Littlefield						
Sitton and Norton Drlg Co	1	btne	270	Wlsn Gnt	270	10,000
Lodi						
Lodi Drlg & Serv Co	3	gas-LPG	—	Wlsn Mogul 42	—	—
	6	dsl	—	Emsco 350	—	—
Menahans						
Texas Drlg Co	1	gas	300	Natl T-20	300	6,000
Odessa						
Beckman Inc	2	gas	185	Beth S-50	185	10,000
	9	gas	185	M-CSCO U-15	350	12,000
	11	gas	300	M-CSCO U-34	300	4,500
J E Perkins Inc	3	gas-LPG	175	Wlsn Gnt	250	10,000
	4	gas-LPG	450	M-CSCO U-15	450	15,000
	5	gas-LPG	400	Wlsn Gnt 42	400	12,500
	6	gas-LPG	450	Wlsn Gnt 42	450	15,000
Rosenberg						
Savely Workover & Drlg Inc	2	LPG-gas	265	Natl T-12	230	11,000/2⅞
	3	LPG-gas	200	M-CSCO U-40	235	12,500
Snyder						
Dave Harlin Drlg Co	1	btne	300	Beth S-45	300	8,000/2⅞"
Stockdale						
Sutton Drlg Co	5	gas-gaso	—	Wlsn	125	3,500
Sulphur Springs						
Dood Emerson Well Serv & Gen Contg	2	LPG	180	Wlsn Spr	145	4,500
Victoria County						
Glenn Drlg Co	3	gas	145	Crdwll S	145	7,000
Ward County						
Pico Drlg Co	1	dsl	368	Brwstr N-4	216	5,000
Waskam						
James R Brown Well Serv	3	LPG	75	Wlsn Spr 38	220	12,000
Wichita Falls						
McAlister Well Serv	16	LPG	80	Reverse Circ Rig	—	6,000
Wink						
Permian Well Serv Inc	1	LPG	200	Crdwll RL	290	12,000
Winkler County						
Pool & Gerlich Drlg Co	D-1	gas	260	M-CSCO U-34	300	5,000
Winnsboro						
Winnsboro Well Serv Co	F-1	btne	145	Frnks Rocket	178	7,200/2½"
	F-2	btne	145	Frnks Rocket	178	7,200/2½"
Wise County						
John Haseman Inc	1	gas-btne	350	Ideco H-35D	300	6,000
	2	gas-btne	150	Wlsn Super	150	3,500
	4	gas-btne	150	Crdwll K-200	150	3,500
WYOMING						
Cody						
Wyoming Well Serv Inc	24	gas	200	Frnks 5039	220	8,000
Converse County						
Dyer Drlg Co	4	dsl	185	Failing 66	300	3,500
Natrona County						
Big Horn Drlg Co Inc	1	dsl	320	Brwstr N-4	290	5,500
J D Sprecher	5	dsl	350	Brwstr N-45	350	6,500

Some Casing Pulling Equipment

Contractor's Name	Rig No.	Description of Casing Pulling Equipment
TEXAS		
Houston		
Stewart's Casing Crew	1	Truck Mounted Unit equipped with 150 ton hydraulic jack to pull casing to 8000 ft on all P & A work
	7	Truck Mounted Unit, equipped with 150 ton hydraulic jack to pull casing to 10,000 ft on all P & A work
Kilgore		
Potter Bros	1	Wlsn Spr single drum servicing unit available for casing pulling jobs
	2	Crdwll single drum servicing unit available for casing pulling jobs
Midland		
Dean Penick	—	Two casing pulling rigs complete: Wlsn Spr single-drum truck-mounted. Pulling capacity; 150,000 lb on mast pole; 300,000 lb on jacks.
Snyder		
C E Knight & Co	—	3 truck-mounted units, range 3 pipe. Handle rods, tubing, mudding hole, spotting cement, circulating and shooting. 2 large rigs for pulling and plugging to 16,000 ft. A smaller unit for 8,000 ft jobs. Hydraulic jacks.

Canadian Well Servicing Contractors

Alphabetical List

B

Beta Well Serv Ltd 5930 96 St Edmonton Alberta Canada

C

Calgary Oil Field Serv Ltd 133 6th Ave SE Calgary Alberta Canada

J

Jennings Drlg Co (Alberta) Ltd 133 Sixth Ave SE Rm 201 Calgary Alberta Canada

K

Kenyon's Drlg & Serv Ltd 10439 82nd Ave Edmonton Alberta Canada

P

Prairie Well Serv Co Ltd Box 4177 Edmonton Alberta Canada

R

Redwell Serv Co Ltd 6530 100th St Edmonton Alberta Canada

S

Souris Serv Co Ltd 940 8th Ave West Calgary Alberta Canada

W

Widney Oil & Drlg Co Ltd 6328 104th St Edmonton Alberta Canada

Canadian Contract Well Servicing or Pulling Units

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity: Swabbing	Estimated Capacity: Pulling	Can Unit Also Drill?
ALBERTA PROVINCE							
Devon							
Kenyon's Drlg & Serv Ltd	7	Crdwll U	Truck	2	6,000	5,000/2½" 4,000/3"	Yes
Widney Oil & Drlg Co Ltd	1	Ideco H-20	Truck	2	9,000	10,500/2" 9,000/2½" 5,500/3"	Yes
	6	Wlsn Spr	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
	9	Wlsn Spr	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
	10	Frnks Rocket 44	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
	12	Ideco H-35	Self-Prop	2	15,000	18,000/2" 15,000/2½" 8,000/3"	Yes
Drayton Valley							
Beta Well Serv Ltd	8	Crdwll K-201	Truck	2	—	10,000/2" 8,500/2½"	Yes
	10	Crdwll K-201	Truck	2	—	10,000/2" 8,500/2½"	Yes
Kenyon's Drlg & Serv Ltd	9	Crdwll AR	Truck	2	7,000	7,000/2½"	Yes
Edmonton							
Beta Well Serv Ltd	6	Crdwll AH	Truck	2	—	6,000/2" 5,000/2½"	Yes
	9	Cooper W-26	Truck	2	5,000	3,500/2½"	Yes
Kenyon's Drlg & Serv Ltd	4	Crdwll Mblhst	Truck	2	5,000	5,000/2½"	Yes
	5	Frnks Sr	Self-Prop	2	12,000	10,000/2½"	Yes
Prairie Well Serv Co Ltd	1	Crdwll H	Truck	1	6,000	6,000/2" 5,000/2½" 4,000/3"	No
	2	Crdwll H	Truck	1	6,000	6,000/2" 5,000/2½" 4,000/3"	No
	3	Crdwll Mblhst	Self-Prop	2	6,500	6,500/2" 5,500/2½" 4,500/3"	Yes
	5	Crdwll KL	Skid Mtd	2	15,900	12,000/2" 10,000/2½" 7,000/3"	Yes
	6	Crdwll RL	Skid Mtd	2	14,000	14,000/2" 12,000/2½" 10,000/3"	Yes
	9	Frnks	Truck	2	14,000	14,000/2" 12,000/2½" 10,000/3"	Yes
	10	Cooper	Self-Prop	2	9,000	10,000/2" 9,000/2½" 7,000/3"	Yes
Redwell Serv Co Ltd	1	Crdwll H	Truck	1	9,000	7,000/2" 5,000/2½" 3,500/3"	No
	14	Frnks Rocket	Truck	2	12,000	10,000/2½"	—
Pembina							
Redwell Serv Co Ltd	5	Crdwll AL	Truck	2	9,000	7,000/2" 5,000/2½" 3,500/3"	Yes
	3	Crdwll H	Truck	2	9,000	7,000/2" 5,000/2½" 3,500/3"	Yes
	10	Frnks Rocket 44	Truck	2	9,000	9,500/2" 7,000/2½" 5,000/3"	Yes
Pincher Creek							
Kenyon's Drlg & Serv Ltd	8	Frnks Sr	Self-Prop	2	12,000	14,000/2½"	Yes
Red Deer							
Kenyon's Drlg & Serv Ltd	2	Crdwll H	Truck	2	6,000	5,000/2½"	Yes
Redwell Serv Co Ltd	6	Crdwll AH	Truck	2	9,000	7,000/2" 5,000/2½" 3,500/3"	Yes
	7	Frnks Rocket 44	Truck	2	9,000	9,500/2" 7,000/2½" 5,000/3"	Yes
	9	Frnks Clpr 65	Truck	2	9,000	13,000/2" 10,000/2½" 7,000/3"	Yes
	11	Frnks Rocket 44	Truck	2	9,000	9,500/2" 7,000/2½" 5,000/3"	Yes
Redwater							
Beta Well Serv Ltd	2	Crdwll H	Truck	1	—	5,000/2" 4,000/2½"	Yes
	3	Crdwll Mblhst	Truck	2	—	5,000/2" 4,000/2½"	Yes
Stettler							
Prairie Well Serv Co Ltd	4	Ideco 50-60	Truck	2	7,000	7,000/2" 6,000/2½" 5,000/3"	Yes
Redwell Serv Co Ltd	2	Crdwll H	Truck	1	9,000	7,000/2" 5,000/2½" 3,500/3"	No
Sundre							
Redwell Serv Co Ltd	8	Frnks Clpr 65	Truck	2	9,000	13,000/2" 10,000/2½" 7,000/3"	Yes
Wetaskwin							
Calgary Oil Field Serv Ltd	1	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	Yes
	2	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	Yes
	3	Wlsn Mogul 42	Truck	2	12,000	10,000/2½"	Yes
	4	Wlsn Mogul 42	Truck	2	12,000	10,000/2½"	Yes
BRITISH COLUMBIA PROVINCE							
Ft. St. John							
Calgary Oil Field Serv Ltd	1	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	Yes
	2	Wlsn Spr 38	Truck	2	12,000	10,000/2½"	Yes
	3	Wlsn Mogul 42	Truck	2	12,000	10,000/2½"	Yes
	4	Wlsn Mogul 42	Truck	2	12,000	10,000/2½"	Yes
Kenyon's Drlg & Serv Ltd	3	Frnks 658	Truck	2	9,000	7,000/2½"	Yes
SASKATCHEWAN PROVINCE							
Coleville							
Kenyon's Drlg & Serv Ltd	6	Frnks Rocket	Truck	2	4,000	4,200/2½"	Yes
Estevan							
Souris Serv Co Ltd	1	Crdwll AL	Truck	2	5,000	5,000/2"	Yes
	4	Mayhew 2000	Truck	2	5,000	2,000	Yes
Widney Oil & Drlg Co Ltd	7	Cooper W-226	Truck	2	5,000	3,000/2½"	No
	8	Wlsn Spr	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
	11	Frnks Rocket 44	Truck	2	9,000	8,000/2" 6,500/2½" 4,000/3"	Yes
Oxbow							
Souris Serv Co Ltd	2	Frnks Rocket	Truck	2	6,000	6,000/2½"	Yes
	3	Crdwll AL	Truck	2	5,000	5,000/2½"	Yes
	4	Mayhew 2000	Truck	3	5,000	5,000/1¼"	Yes
Weyburn							
Souris Serv Co Ltd	1	Crdwll AL	Truck	2	5,000	5,000/2½"	Yes
	3	Crdwll AL	Truck	2	5,000	5,000/2½"	Yes

Canadian Cable Tool Servicing Rigs

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
ALBERTA PROVINCE						
Edmonton						
Prairie Well Serv Co Ltd	5	gas	140	2	7000	Crdwll KL
	6	dsl	185	2	12,000	Crdwll RL

Canadian Rotary Workover Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Workover Depth, Ft
ALBERTA PROVINCE						
Alberta						
Jennings Drlg Co (Alberta) Ltd	1	dsl	300	Beth C-50	300	6,000 7,000/3½"
	2	dsl	300	Beth C-50	300	6,000 7,000/3½"
	3	dsl	880	M-CSCO U-15	880	9,000 10,000/3½"
Edmonton						
Prairie Well Serv Co Ltd	5	gas	140	Crdwll KL	140	7,000
	6	dsl	185	Crdwll RL	185	12,000
	9	dsl	185	Frnks	225	12,000
	10	gas	230	Cooper	232	9,000
Redwell Serv Co Ltd	12	dsl	260	Crdwll L	180	10,000
	13	dsl	260	Crdwll L350	260	13,000
Stettler						
Prairie Well Serv Co Ltd	4	gas	140	Ideco 50-60	140	6,000
SASKATCHEWAN PROVINCE						
Estevan						
Kenyon's Drlg & Serv Ltd	12	dsl	—	Frnks Comet 658	250	9,000
Souris Serv Co Ltd	1	dsl	—	Crdwll AL	114	5,000/2⅛"
Oxbow						
Souris Serv Co Ltd	2	dsl	—	Frnks Rocket	114	5,000/2⅛"
Swan Hills						
Kenyon's Drlg & Serv Ltd	11	dsl	—	Crdwll 151	350	10,000
Weyburn						
Souris Serv Co Ltd	3	gas	—	Crdwll AL	144	5,000/2⅛"

ADDITIONAL LISTINGS

U. S. Contract Rotary Drilling Rigs

H Davis & R H Thompson Co 1731 28th St Bakersfield Calif
Buster Gardner Drlg Co Inc Box 281 New Iberia La
Tom Jack Drlg Co Box 288 Sulphur Okla
Gore Drlg Co Box 515 Albany Tex

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
CALIFORNIA						
Kern County						
H Davis & R H Thompson Co	1	dsl	300	Emsco G-300	300	6,000
Los Angeles County						
H Davis & R H Thompson Co	2	dsl	300	Emsco GA-250-T	300	6,000
LOUISIANA						
Terrebonne Parish						
Buster Gardner Drlg Co Inc	1	dsl	—	Beth M-58	—	9,500
Vermilion Parish						
Buster Gardner Drlg Co Inc	2	dsl	—	Beth Tornado	—	15,000
St Mary Parish						
Buster Gardner Drlg Co Inc	3	dsl	—	Beth 1013	—	17,500
OKLAHOMA						
Marshal County						
Tom Jack Drlg Co	4	dsl	200	Crdwll S-350	200	5,000/3½"
Stephens County						
Tom Jack Drlg Co	5	dsl	200	Crdwll S-350	200	5,000
TEXAS						
Shackelford County						
Gore Drlg Co	1	dsl	640	Shovel Spl	—	7,500
	2	dsl	320	Beth	—	5,000
	3	gas	254	Joy 200-A	—	2,500/2⅛"

U. S. Contract Cable Tool Drilling Rigs

K Smith Cable Tool 1801 Van Buren Great Bend Kans

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
KANSAS						
Graham County						
K Smith Cable Tools	1	gas-prop	145	3000	5000	Wlkr-Nr

Canadian Contract Rotary Drilling Rigs

Able Drlg Co Three Hills Alberta Canada

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALBERTA PROVINCE						
Three Hills						
Able Drlg Co	10	gaso	40	Failing 1500	—	1,500/2⅛"
	30	gaso	46	Wntr Weiss 500	—	1,500/2⅛"
Swan Hills						
Able Drlg Co	20	gas	46	Mayhew	—	1,800/2⅛"

U. S. Contract Well Servicing or Pulling Units

Douglas V Downing Well Serv Box 206 Devine Tex

Contractor's Name	Rig No.	Make & Model No. of Unit	How Unit is Transported	No. of Drums	Estimated Capacity Swabbing	Estimated Capacity Pulling	Can Unit Also Drill?
TEXAS							
Devine County							
Douglas V Downing Well Serv	1	Border Foundry	Truck	2	4,500	4,000/2" 3,500/2½" 2,500/3"	No
	3	Wlsn Spr	Truck	2	7,000	7,000/2" 6,500/2½" 5,500/3"	Yes
	4	Wlsn Spr	Truck	2	7,000	7,000/2" 6,500/2½" 5,500/3"	Yes
	6	Wlsn Sr	Truck	2	6,000	5,000/2" 4,500/2½" 3,500/3"	Yes
Frear County							
Douglas V Downing Well Serv	2	Wlsn Spr	Truck	2	7,000	7,000/2" 6,500/2½" 5,500/3"	Yes
	5	Frnks	Truck	2	4,500	4,000/2" 3,500/2½" 2,500/3"	No
Rotary Workover Rig							
Devine County							
Douglas V Downing Well Serv	7	LPG		250	Wlsn Spr	185	8,500

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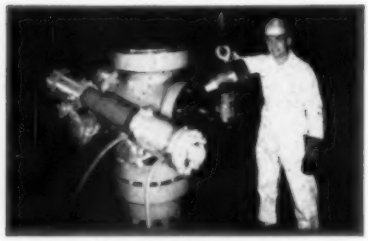

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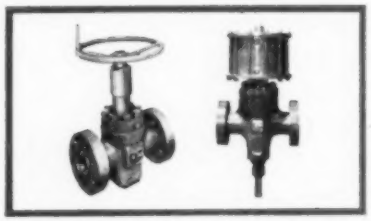

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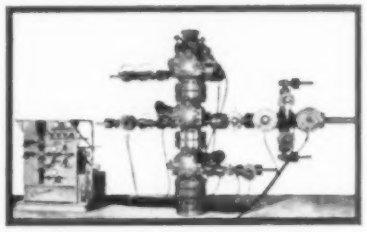

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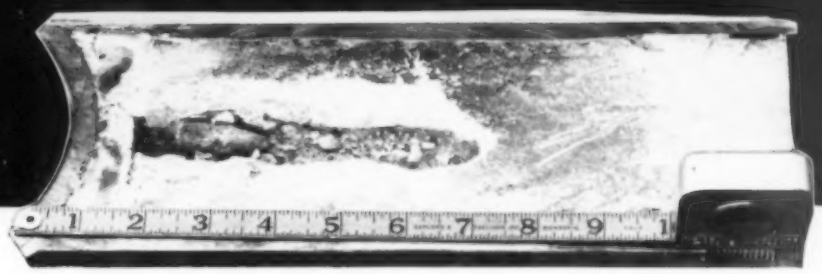

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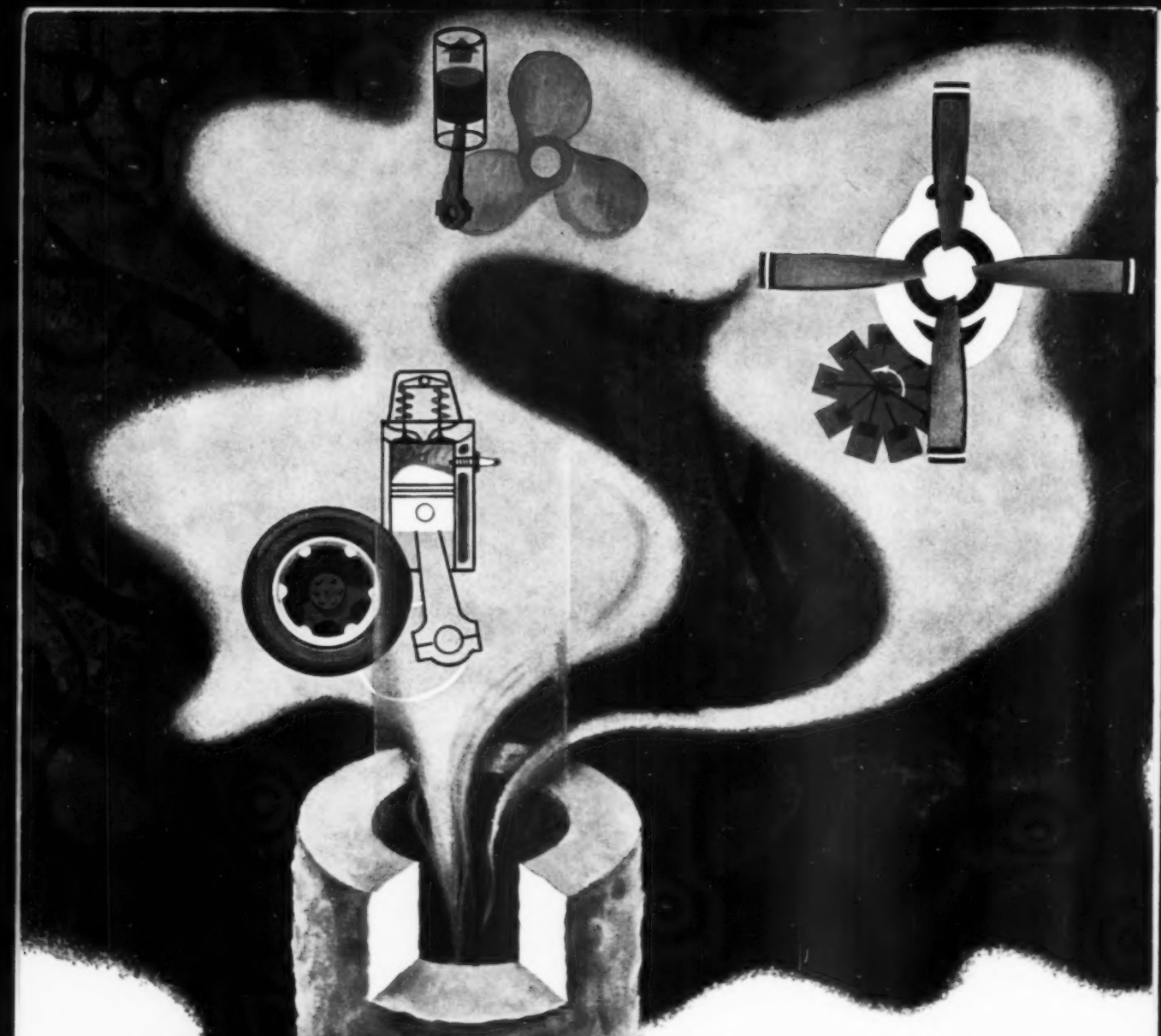

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